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USE OF AMMONIUM NITRATE IN POTATO FERTILIZERS

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INTRODUCTION

It is estimated that the supply of fertilizer nitrogen available to American farmers next season (1943-'44) will be approximately 35 per cent greater than that in any previous year, thereby allaying any fears of a shortage of this essential nutrient element. This will mean more nitrogen for mixed fertilizers and for direct application as top- and side-dressings. No doubt this information will be of interest to potato growers who use annually close to one-tenth of the complete fertilizer used in the United States, costing them approximately 20 to 25 million dollars. One of the reasons for this increase in fertilizer nitrogen is the diversion of ammonium nitrate produced at war plants to agricultural purposes. This is indicated in a recent article by Parker and Ross[2] who stated:

> Ammonium nitrate is now available for fertilizer purposes from private and war plants. Increased supplies will be available in future years for ammonium nitrate is the form of nitrogen war plants produce that

[1]Senior Biochemist.

[2]The numbers in parentheses refer to the literature cited at the end of the paper.

can be readily used in fertilizer. Its effective use is a problem the industry will face next year and in the years to follow.

Use of Ammonium Nitrate Presents Problems

Two main questions arise when it comes to using any compound or material for fertilizer purposes: Does it compare favorably with standard fertilizer materials as a plant nutrient? Does it possess desirable physical properties? The first question as to whether ammonium nitrate qualifies as a source of nitrogen for potatoes is important. The answer to this question, in view of prospective large supplies of this compound, should be of interest to farmers in general. It is the purpose of this paper, first, to call attention to the results of 27 field experiments, comparing ammonium nitrate, ammonium chloride, ammonium sulfate, sodium nitrate, and urea as sources of nitrogen in potato fertilizer and, second, to consider briefly the physical properties of ammonium nitrate fertilizers. The latter point is of special interest to farmers who do home mixing or use nitrogen top- and side-dressings.

Results of Field Experiments[3]

The field comparisons were made in Maine, New York (L. I.), Pennsylvania, and Virginia on important potato soils. Information as to yields, location of experiments, number of tests, soil type, variety grown, and fertilizer used is given in table 1.

An examination of the results shows that ammonium nitrate gave a good account of itself with the highest average yield of any of the nitrogen sources compared. On the basis of average yields for all 27 field tests the ammonium nitrate mixture produced 241 bushels per acre; urea, 238; ammonium chloride, 237; ammonium sulfate, 235; and sodium nitrate, 232.

Other Work Reported

Wessels and White-Stevens (2) conducted a nitrogen-source study for 3 years (1935-'37) on Long Island, comparing ammonium nitrate, ammonium sulfate, sodium nitrate, and urea as sources of nitrogen for potato and spinach fertilizers. Their results for potatoes showed no marked yield differences. The ammonium nitrate mixture produced

[3]Results obtained from field studies conducted cooperatively by the U. S. Department of Agriculture and the Maine, New York (Cornell), and Pennsylvania Agricultural Experiment Stations, and the Virginia Truck Experiment Station.

TABLE 1—*Potato yields obtained with various sources of nitrogen.*

Location of Experiments	No. of Tests	Variety Grown	Soil Type	Fertilizer Used*		Average Yields in Tests with Various Sources of Nitrogen, and General Averages				
				Analysis	Rate per Acre	Ammonium Nitrate	Ammonium Chloride	Ammonium Sulfate	Sodium Nitrate	Urea
					Pounds	Bushels per Acre	Bushels per Acre	Bushels per Acre	Bushels per Acre	Bushels per Acre
Maine Aroostook Co.	6	Irish Cobbler	Caribou loam	4-8-8	1,800	311	311	290	279	313
New York Suffolk Co.	3	Green Mountain	Sassafras loam	4-8-8	1,800	262	247	237	263	259
Do	2	Irish Cobbler	do	4-8-8	1,800	276	263	255	250	267
Pennsylvania Cambria Co.	5	Russel Rural	Muskingum stony loam	4-8-8	800	203	208	199	203	188
Pennsylvania Mercer Co.	4	do	Volusia silt loam	4-8-8	800	261	251	271	257	252
Pennsylvania Lehigh Co.	3	do	Berks shale loam	4-8-8	1,200	193	197	204	213	191
Virginia Northampton Co.	4	Irish Cobbler	Sassafras sandy loam	6-8-6	1,800	169	161	174	154	181
			Weighted average			241	237	235	232	238

*Other fertilizer ingredients in the 4-8-8 mixture included: Superphosphate (18% P_2O_5); potassium sulfate (50% K_2O); sand for filler.

the highest average yield, 268 bushels per acre; urea, 260 bushels; ammonium sulfate, 257 bushels; and sodium nitrate, 254 bushels. In their study the Cobbler variety was grown and a 5-8-5 fertilizer used at the rate of a ton per acre.

Physical Properties

Considering the second question, "Does ammonium nitrate possess desirable physical properties?": This question does not primarily concern the user of ready-mixed fertilizers containing ammonium nitrate, since such mixtures can be compounded in such a manner that their physical condition will be satisfactory. It is, however, of great importance to the home mixer or to any one who may want to use ammonium nitrate for direct application. It is recognized that ordinary ammonium nitrate possesses two properties that have heretofore operated against its successful use for direct application. First, it absorbs moisture from the air more readily than the general run of fertilizer materials and, secondly, it tends to cake when put in storage. Obviously, the main job confronting fertilizer technologists is to condition ordinary ammonium nitrate to minimize these objectionable properties. It is encouraging to note that considerable progress toward the accomplishment of this objective has been made and that the so-called new forms of ammonium nitrate are a great improvement over the ordinary form.[4]

Summation

Ammonium nitrate will be more extensively available to fertilizer consumers in the ensuing season (1943-'44) than in any previous year. Much of this increase will be due to larger supplies of ammonium nitrate resulting from war plant activities. Ordinary ammonium nitrate absorbs moisture readily from the air, and it tends to cake in storage. Studies to alleviate these tendencies are showing considerable promise of success. Aside from getting the material in suitable physical condition and maintaining it so, the question concerning its nutrient value is of importance.

Twenty-seven field tests were made to compare ammonium nitrate, ammonium chloride, ammonium sulfate, sodium nitrate, and urea as sources of nitrogen for potato fertilizers. On the basis of general averages, ammonium nitrate proved slightly superior, but the differences at

[4]To obtain information concerning the technical processes involved in getting ordinary ammonium nitrate into better physical condition, the reader is referred to the Division of Soil and Fertilizer Investigations, Bureau of Plant Industry, Soils, and Agricultural Engineering, Plant Industry Station, Beltsville, Md.

best were small. This is indicated by the narrow range in yields, 232 bushels for sodium nitrate, with the lowest average yield, and 241 bushels for ammonium nitrate, with the highest average yield.

So far as the potato crop is concerned, the results presented herein indicate clearly that ammonium nitrate rates high as a source of nitrogen for potatoes.

Literature Cited

1. Parker, F. W., and Ross, W. H. 1943. Problems in formulating fertilizers for 1943-'44. American Fertilizer, Vol. 99, Issues of July 3 and July 17.
2. Wessels, P. H., and White-Stevens, R. H. 1938. Various sources of nitrogen for potatoes and spinach. Proc. Amer. Soc. for Hort. Sci. 36:593-596.

NON-VIRUS LEAFROLL OF IRISH POTATOES[1]

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Introduction

A leaf rolling herein designated as non-virus leafroll, which is very similar to virus leafroll often appears in Irish potato varieties and seedling varieties under southern conditions. It is observed almost every spring in plants from tubers of seedlings which had been grown from true seed in pots the previous fall.

In some varieties only the lower leaves roll, whereas in others the rolling may also extend to the upper leaves. The extent of rolling varies from a slight cupping to a tightly rolled condition (Fig. 1). Such rolled leaves do not possess the brittleness of virus-leafroll-infected plants, and yielding ability appears not to be materially affected by this type of rolling.

The factors favoring the expression of this type of leafroll are not completely understood. However, the data herein reported indicate that it is a heritable character. It is probable that the expression is conditioned by environmental factors and the interaction of length of storage period and dormancy.

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[1]Cooperative investigations by the Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration, United States Department of Agriculture, and the Department of Horticultural Research of the Louisiana Agricultural Experiment Station.

[2]Pathologist.

Evidence of Non-Virus Nature of Rolling

It is well known that the severity of rolling in virus leafroll usually becomes greater the season following infection, and the reduction in yield is probably proportional to severity of rolling. Furthermore, virus leafroll results in the production of a high percentage of small-size tubers.

Evidence on the question of whether or not the leafroll under study is a virus was obtained from a yield test of 15 seedling varieties made in the fall of 1940. The tubers of all lots used to plant this test in the fall were one generation removed from true seed and had been grown together for increase the previous spring on a small isolated block of land. These potatoes had been rogued three times during the spring. At the time of harvest of the fall-yield test, samples of 10 medium-sized tubers were taken from each of the 45 plots (15 seedling varieties and 3 replications of each) for planting in the spring of 1941. The severity of rolling of each seedling variety in each replication was recorded in the fall crop and also in the subsequent spring crop (Table 1). The percentage of prime potatoes was calculated from the yields after grading the spring crop.

Table 1—*Degree of leaf rolling in 15 seedling varieties of Irish potatoes in the fall of 1940 and amount of leaf rolling and percentage of prime potatoes in the following spring at Baton Rouge, Louisiana. (Averages of 3 replications).*

Seedling Varieties	Average Degree of Leaf Rolling in Fall of 1940[1]	Average Degree of Leaf Rolling in Spring of 1941[1]	Average Percentage of Primes in Spring of 1941
1	3.0	3.0	88
2	3.0	3.0	85
3	2.3	2.3	89
4	2.0	2.[illegible]	85
5	1.8	2.0	81
6	1.3	2.0	90
7	1.3	2.0	85
8	1.3	2.0	86
9	1.0	1.0	83
10	0.7	1.0	80
11	0.7	1.0	93
12	0.7	1.3	81
13	0.7	1.0	89
14	0.3	1.0	88
15	0.0	0.3	90

[1] 0 = no leaf rolling; 1 = slight; 2 = moderate; 3 = severe.

The aphid population during the fall of 1940 was quite high and conditions were favorable for spread of leafroll. Generally speaking the spinach aphid, which is the common vector in Louisiana, is more prevalent during the fall than during the spring at Baton Rouge, Louisiana.

If the leaf rolling were caused by a virus one would expect the amount of rolling to be greater in the spring crop than in the previous fall crop and a reduction in percentage of prime potatoes in the spring crop would result. That such a relationship was not present in the material tested is apparent from the data present in table 1. It is significant that the increase, if any occurred, in rolling of any seedling variety in the spring crop as compared with the fall crop was only slight. If this leaf rolling had been caused by a virus, one would have expected a greater increase in the degree of rolling in the spring crop than that obtained in these studies.

The data on percentage of primes, as shown in table 1, in the spring crop are particularly convincing. Thus, seedling varieties 1 and 2 had severe rolling in both the fall and spring crops and despite this condition, the percentages of primes were 88 and 85 per cent, respectively.

It has been found that during the first 2 roguings the virus-leafroll plants can be readily detected. After these plants are removed in the early stage of development one can be quite certain that plants developing a roll of the leaves later in the season are probably affected with non-virus leafroll. Without this early elimination of virus-leafroll plants the writer is not able to differentiate with any degree of certainty these two conditions later in the season. With seed stocks that are known to be relatively free from virus-leafroll one can be certain of non-virus leafroll in later stages of development if every plant in a clonal line is rolled.

The above procedure was used as an aid in detecting non-virus leafroll plants in the work herein reported.

As a check on the ability to distinguish non-virus from virus leafroll a number of stem-grafting tests were made with plants regarded as being affected with non-virus leafroll, using healthy Triumph variety as the scion. Tubers produced in the fall of 1940 and in the spring of 1941 from plants exhibiting what was classified as moderate and severe non-virus leafroll were included in these tests together with virus-infected and non-infected controls.

The results of these grafting tests are presented in table 2. Of the 41 inoculations made from fall-grown tubers five plants or 12.2 per cent were affected with virus leafroll. The entire 11 plants tested from spring-grown stocks were free from virus leafroll. Of the tubers thought

to be infected with virus-leafroll used as controls, 87.5 per cent were shown to be infected. None of the healthy Triumph used as scion material was found to be infected. Thus the above-mentioned method of

TABLE 2—*Results of test-graft inoculating healthy Triumph potato plants with material regarded as affected with non-virus leafroll.*

Number of Seedlings or Varieties Tested	Number of Plants		Percentage of Plants Infected
	Grated	Infected with Virus Leafroll	
	Fall-grown stock		
7	41	5	12.2
	Spring-grown stock		
2	11	0	0.0
	Control (Leafroll-infected plants)		
1	8	7	87.5
	Control (Healthy Triumph plants)		
1	8	0	0.0

TABLE 3—*Extent of non-virus leafroll in seedling Irish potato varieties at Baton Rouge, Louisiana, in the spring of* 1941. (*Test consisted of* 3 *replicated plots of each variety*).

Variety	Parentage	Average Degree of Rolling[1]
X926-102	Katahdin x Earlaine	3.0
0-50	Early Rose x Katahdin	3.0
S 47207	S 46019 x Earlaine	3.0
S 47528	S 46165 x Earlaine	3.0
S 47512	S 45146 x Earlaine	3.0
C.S. 125	Russet Rural x Katahdin	3.0
S 47096	S 45146 x Earlaine	2.7
X 926-44	Katahdin x Earlaine	2.3
S 47102	S 45146 x Earlaine	2.0
S 47248	Chippewa x Earlaine	2.0
S 47518	S 46165 x Earlaine	2.0
S 47499	S 47005 x 46923	1.7
X926-13	Katahdin x Earlaine	1.7
Katahdin	S 24642 x S 40568	1.7
S 47557	(X336-123) x S 46422	0.0

[1]0 = no rolling; 1 = slight; 2 = moderate; 3 = severe.

classifying plants for non-virus leafroll has been quite satisfactory when one considers the many complications involved in such work.

Varietal Reaction

The extent of non-virus leafroll in a number of seedlings and commercial varieties was determined in the spring of 1940 at Baton Rouge, Louisiana. The data are presented in tables 3 and 4.

Table 4—*Extent of non-virus leafroll in varieties of Irish potatoes at Lafayette and Baton Rouge, Louisiana, in the spring of* 1941. (*Test consisted of 3 replicated plots of each variety at each location*).

Variety	Average Degree of Rolling[1] Location		Means of 2 Location[1]
	Lafayette	Baton Rouge	
Chippewa	3.0	3.0	3.0
S46000	2.0	2.7	2.3
Katahdin	2.0	2.0	2.0
Sebago	2.0	2.0	2.0
Triumph	1.7	2.0	1.8
Cobbler	1.3	1.7	1.5
Red Warba	1.3	1.3	1.3
Houma	1.0	1.3	1.2
Warba	1.0	1.3	1.2
Sequoia	1.0	1.0	1.0
Earlaine	0.7	1.0	0.8
Green Mountain	0.3	1.0	0.6
Pontiac	0.0	1.0	0.5

[1]0 = no rolling; 1 = slight; 2 = moderate; 3 = severe.

Of the 14 seedling varieties tested (Table 3) only S-47557 was entirely free of rolling in all the replications (Fig. 2). The rolling in the others ranged from a moderate to a severe type (Fig. 1).

From the data in table 4 it appears that none of the 12 named varieties and 1 seedling variety was entirely free from rolling. Earlaine, Green Mountain, Houma, Pontiac, Red Warba, Sequoia, and Warba, however, showed only slight rolling. At the time the notes were taken, only the lower leaves of Katahdin were rolled (Fig. 3), whereas the rolling extended to the upper leaves of Chippewa (Fig. 4).

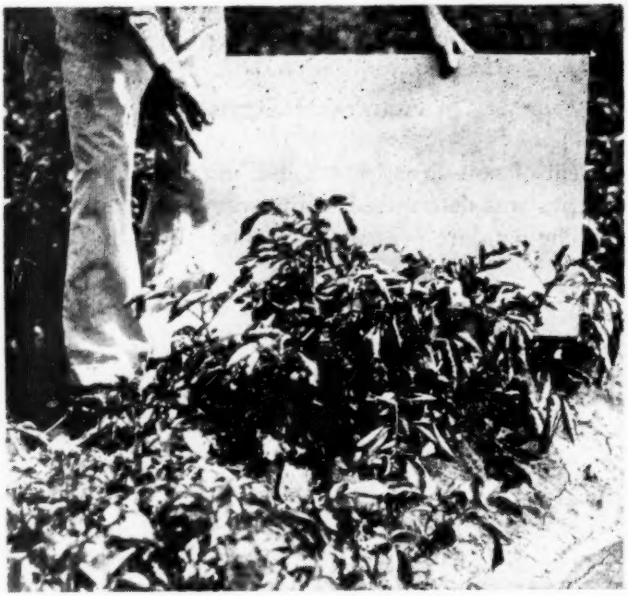

FIGURE 1.—Severe type of rolling in seedling 926-102.

FIGURE 2.—Seedling 47557 which is not subject to non-virus leafroll.

FIGURE 3.—Non-virus leaf rolling in Katahdin, which is largely limited to the lower leaves.

FIGURE 4.—Non-virus leaf rolling in Chippewa, which extends to the tip of the plant

It would seem that any seedling or variety with a type 1 leafrolling reaction or less, would be suitable from the standpoint of commercial characteristics. Rolling greater than type 1, probably would make roguing difficult because of possible confusion with virus leafroll.

Leaf Rolling in Progenies of Potatoes

The presence of rolling was also determined in 17 progenies from crosses and inbred lines of potatoes. These data are presented in table 5.

Table 5—*Percentage of plants with non-virus leafroll in progenies of* 14 *crosses and* 3 *inbred lines of Irish potatoes at Baton Rouge, Louisiana, in the spring of* 1941.

Cross or Inbred	Size of Progeny	Segregates Showing Rolling	
		Number	Percentage
Katahdin x Earlaine	38	33	86.8
S47303 x Earlaine	98	63	64.3
S41956 x Katahdin	44	29	65.9
Triumph x Katahdin	205	140	68.3
President x Katahdin	32	27	84.4
S47399 x Katahdin	91	62	68.1
Spaulding Rose x Katahdin	64	33	51.6
(X336-302) x Katahdin	58	35	60.3
Early Rose x Sebec	146	116	79.4
Earlaine x Sebec	119	94	79.0
Chippewa x Sebec	90	56	62.2
X926-66 x Sebec	92	56	60.9
(3897-90) x (X336-18)	107	96	89.7
Ackersegen x (X336-7 selfed)	152	40	26.3
Katahdin selfed	95	48	50.5
Earlaine selfed	147	64	43.5
S 47454 selfed	53	4	7.5

The size of some of the progenies is small and therefore inadequate for genetic interpretation. It is significant, however, that they differ considerably in the percentage of segregation for rolling. Freedom from rolling was transmitted to a high percentage of the progeny in a few crosses. That Katahdin and Earlaine are not homozygous for freedom from rolling is evident by the fact that 50.5 and 43.5 per cent, respectively of the segregates in selfed lines were rolled. From these inbred progenies, it appears that Katahdin and Earlaine may be genotypically similar for this character.

The progenies of the crosses of Early Rose x Sebec, Earlaine x Sebec, and Chippewa x Sebec segregated in about the same manner for non-virus leafrolling. Therefore, Early Rose, Earlaine, and Chippewa are probably genotypically similar for this character. Phenotypically, Early Rose, Earlaine and Sebec are similar, being less subject to rolling than Katahdin. Chippewa, however, rolls to a greater degree than any of the varieties tested.

It is particularly significant to note that a progeny of selfed S47452 had only 7.5 per cent of rolled segregates.

Discussion and Summary

Non-virus leafroll, which is very similar to virus leafroll, often appears in Irish potato seedling varieties under southern conditions. This same condition is observed nearly every spring in first tuber propagations from seedlings grown from true seed in pots the previous fall. The data reported indicate that it is a heritable character. It is probable that its expression is conditioned by environmental factors and the interaction of length of storage period and dormancy.

Results are presented showing the response of a number of seedling and named varieties, and progenies of these, to this type of leaf rolling. Although the data are inadequate for a genetic interpretation, they are sufficient for recommendations from the standpoint of a potato-breeding program.

Marked differences in the degree of rolling were found in seedling and named varieties. A few of the varieties tested were relatively free from or not subject to this rolling. Progenies from crosses and inbred lines differed considerably in the percentage of segregates subject to rolling. Freedom from rolling was transmitted to a high percentage of the progeny in a few crosses or inbreds. This definitely indicates that it should be possible to select seedlings that are free from non-virus leafroll and to combine freedom from rolling with other desirable characters.

The non-virus nature of this rolling is indicated by the fact that (1) no appreciable increase in degree of rolling occurred with continued propagation of the seedlings or varieties; (2) the percentage of primes is maintained with continued propagation; (3) almost without exception every plant of a particular seedling or commercial variety, if subject to rolling, is affected to approximately the same degree; and (4) stem-graft tests substantiated observational differentiation between non-virus and virus-leafroll to a high degree.

POTATO RING ROT CONTROL FOR THOSE WHO THINK THEY DON'T HAVE THE DISEASE

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Four discoveries of ring rot have been made in 1943 in fields in New York State entered for certification and which were planted with certified seed. In each case the grower was surprised as well as pained as there seemed to be no good reason why he should expect to have it. In previous years similar discoveries have been made. In some cases it is possible to make a hindsighted guess as to where the disease came from or by what agency it was introduced. In most cases, the grower has not been more careless than most other seed growers who have been more fortunate. The conclusion seems inescapable that, while many growers don't have the disease there is not a single grower who is known not to have it nor any who can be sure he will not get it.

In cases where seed-potato growers are taking precautions against ring rot, the measures taken are largely negative. Such measures are: *not* buying seed known to contain ring rot nor any uninspected seed; *not* using planters from farms where ring rot is prevalent; and *not* using second-hand bags, etc. These measures may be sufficient to guard their stock against gross contamination. However, if ring rot is present in the neighborhood or if seed is purchased from areas where ring rot is present, it seems certain that, in time, minute amounts of disease will be introduced and that these will build up in the course of two or three years to the point where the disease will be detected by the inspector. Any field, previously clean, may become contaminated by the action of some casual passer-by who stops to dig a hill, by a potato picker who walks through a contaminated field on his way to work, or (for all we know to the contrary) by some insect or animal. It seems utterly impossible that every seed grower will succeed in completely excluding this bacterium forever. For this reason, some growers have indicated discouragement with regard to replacement of infected seed, arguing that there is no greater reason for confidence in the new source than there had been in the old.

It is the opinion of the writer that a positive program can be developed by which a grower can produce, every year, seed that is so free from ring rot that it can safely be used on his farm. This program is not designed to displace the recommendation that any source of seed known to contain ring rot be completely discarded nor is it intended to permit the relaxation of those measures usually taken to prevent the

introduction of the disease. It is meant to take care of the very rare infected hill, the presence of which is not even suspected. It is not expected that the general run of potato growers will adopt such a program or even that any large proportion of certified-seed growers will do so. This proposed program is based upon the following assumptions:

1. That where the amount of ring rot is more than 1 hill in 10,000 its presence will be discovered either by the grower or the inspector and the entire stock discarded.

2. That the cutting knife is by far the most efficient agent of transmission, the planter also being capable of serious transmission and also probably the digger.

3. That other agents of transmission are not efficient enough to endanger seriously a small plot planted with clean seed even if planted in the neighborhood of a field containing not more than one diseased plant in 10,000.

4. That where the amount of disease is not more than one hill in 10,000, a small number of hills may be dug with very high probability that they will be free from disease.

The program is based on much the same bacteriological principle as that which has led us to replace the school dipper with a sanitary drinking fountain. The first step is to dig a hundred hills by hand, examining each for symptoms of ring rot. If any is found the attempt should be abandoned. If none is found it is still possible that a ring rot hill has been included, in which case the program will have failed at the outset. The likelihood of either event, however, is very slight. We will assume then that we have 100 healthy hills. The tubers should be picked directly into new crates and kept in these through the winter.

At planting time the tubers should be cut with a knife which has previously been disinfested in boiling water for a period of 5 minutes. The potatoes should be planted by hand to avoid danger of transferring inoculum from other plots into this one. The stock may well be planted in tuber units but this is not an essential part of the program.[1]

[1] In order to keep the program simple, certain precautions have been omitted which may be adopted by those who wish to be especially careful. One of these is the constant disinfestation of the cutting knife, which can be done by the use of a rotary blade, as suggested in Cornell War Emergency Bulletin 113, or by use of four or five knives in rotation, the extra ones being kept in a disinfesting solution. A more effective precaution is seed treatment. Recent experiments at Cornell by L. C. Knorr have indicated that dropping the cut seed pieces directly into acidulated corrosive sublimate solution for 2 to 5 minutes will prevent most transmission. The solution may be made by dissolving 4 ounces of corrosive sublimate in ¼ pint of hydrochloric acid and pouring this into 15 gallons of water, These precautions may be desirable but are not essential.

The resulting plot should consist of 1,000 hills (or more). Such plots are later referred to as being at the highest "level" of increase. In the fall, 100 hills are again dug from this plot and it is suggested that they be the first 100 hills that were planted, as these are less likely to have become contaminated from an unsuspected ring-rot hill included the previous year. The remainder of the 1,000-hill plot is dug with a digger, with due precautions to prevent contamination in field or storage. The third year there will be a 1,000-hill plot planted with the product of the 100 hills dug by hand the year before and a one-acre plot planted with the remaining product of the 1,000-hill plot. Each year thereafter there will be a new 1,000-hill plot and each of the other plots (or lower levels) will have expanded to approximately ten times the area of the preceding year. It will take about 5 years to expand the original 100 hills to 100 acres.

No special precautions are proposed to prevent possible spread from tuber to tuber within any given level of increase, but care should be exercised to prevent possible contamination from a lower to a higher level by knives, planters, diggers, containers, or mixing.

The specific suggestions as to number of hills to harvest are only approximations. A larger number of hills may be dug, if preferred, so as to reduce the number of levels, or years of expansion required. The smaller the assumed percentage of ring rot the larger the sample which may safely be used. Thus if we assume 1 diseased hill in ten acres, a 1,000-hill sample will provide odds of approximately 150 to 1 against a diseased hill being included, although with one dressed hill per acre it takes a 100-hill sample to give the same odds. In most fields the actual amount of diseased plants is zero. Where the disease has just been introduced, often only one or two hills will be affected in the entire field.

Those growers who now follow a seed-plot program are conforming to the main essentials of the program proposed. The question is whether the original or highest level of production is on a small enough scale and whether adequate precautions are taken to prevent higher levels from becoming contaminated. Unless ring rot is present in the neighborhood, or at least suspected, the usual seed-plot technique is probably adequate protection against damage from ring rot. It is suggested, however, that the program be modified to include at least three levels of production taking every precaution to prevent the disease from being prepetuated by reinfection of the higher levels from the lower.

In this article we have outlined a five-year program[2] for the production of seed potatoes, more nearly certain to be free from ring rot than the present general run of certified seed. Essentially the program involves starting with a very small plot, which is expanded each year as rapidly as possible. It is a system of constant replacement of seed, which may have become contaminated, by seed less likely to have become contaminated. The method is not intended to apply to cases where seed is known to be infected, nor has this method been tested experimentally. It is, also, probable that no strictly scientific test of the program as a whole will ever be made. It is proposed as a practical aid to seed growers until better methods of ring-rot control may be worked out.

CUSTOM POTATO SPRAYING IN NEW YORK AIDS THE WAR

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Spraying potatoes to control diseases and insects is an old established practice in extensive potato growing areas. Our New York State growers with five acres or less usually lack the equipment, knowledge, experience and labor to do a good job of spraying. The equipment and labor are not available in war time. They represent 93 per cent of the growers and 53 per cent of the acreage in the state. Insurance against loss from diseases and insects has been obtained for several years by the organization of spray rings where a group of growers use one spraying outfit.

During the past three years a new type of sprayer mounted on a large rubber tire tractor has made possible a larger ring now operated on a custom basis similar to that of the threshing and combine operations. The number of these outfits has increased from 12 in 1941 to 35 in 1943 and there are requests for 35 new outfits making a total of 70 for 1944. Based on past performance these 70 custom outfits will spray

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[2]The program here suggested is very similar to that proposed by Reiner Bonde (Maine Agricultural Exp. Sta. Bul. 411C: 284-5. 1942). His program is designed primarily for those growers who already have the disease in their potatoes and who cannot immediately replace all of their stock with clean seed. It rests on the assumption that seed *known* to be free from ring rot can be purchased. Strictly speaking this assumption is not sound now, and should the disease become more widespread it may become increasingly difficult to obtain disease-free seed unless steps are taken to conserve such sources.

[1]Extension Agricultural Engineer.

about 17,000 acres for some 3,500 growers. With an average increase in yield of 50 bushels per acre in a non-blight year we can expect about 875,000 bushels of potatoes as a result of these large custom spraying operations in 1944. If next year should happen to be another blight year the increase might easily reach 1,500,000 bushels. The large custom spray ring operations also make the most efficient use of critical farm machines and labor as well as increase the food production both of which contribute to the war effort.

The custom sprayer outfit consists of a ten-row tractor-mounted sprayer and a water supply truck equipped with a large tank and water pumping equipment. The outfit is usually owned by the operator who, with his helper on the truck, sprays the grower's potatoes from 6 to 8 times at 7-10 day intervals throughout the season. The grower furnishes no labor or materials and he depends upon the custom operator for the entire spraying job. The operator collects the fee after completing each application. The total cost has been about $2.00 per acre for each 10-10-100 bordeaux application.

Each custom outfit can take care of about 250 acres. By covering ten rows at one time and traveling about three miles per hour continuous spraying would cover 10 acres per hour. However, about one-half the time is used in filling the sprayer, turning at the ends and traveling from field to field so that it takes a full day to cover 50 acres between morning and evening dew. The availability of the water for the truck is an important factor because the sprayer is idle whenever the truck fails to return with the next load of water. When the truck can get water to the field promptly, the sprayer loses very little time because the fine crystal copper sulphate and dry lime are mixed while the water is filling the tanks. The filling operation usually takes from six to eight minutes. The force of the stream from the water pump on the truck seems to be the secret to good mixing of the dry materials into a bordeaux which will not cause clogged strainers and nozzles while spraying. These water pumps are either of the rotary or centrifugal type delivering approximately 100 gallons per minute through a one and one-half inch discharge hose with a short one-inch pipe inserted in the end. This large capacity water pump fills the 700-1,000 gallon truck tank in 7-10 minutes, thus helping to prevent delay in getting supplies back to the sprayer.

The tractor-mounted sprayer is not new because it has been used in Maine since 1931. The use of the rubber tire tractor with a road speed of 18 miles per hour is very essential to these custom ring operations. The unit is very compact and maneuverable under the most ad-

verse field conditions. It can be guided in between the potato rows better than any other type of field sprayer. The spray material is carried in two narrow deep tanks attached to the tractor frame each of which holds 150 gallons. The pump and boom are mounted on a separate frame just behind the tractor driver. The outer boom wings are folded by ropes and pulleys or by hydraulic cylinders on the 1943 outfits. The standard drop pipe boom with three nozzles per row is most commonly used. Some operators have changed to a straight brush type boom similar to that used for weed control. A 30-gallon per minute pump applies 100-125 gallons per acre through three sixty-fourths (No. 3) discs and maintains 400 pounds pressure. The tractor is equipped with six ply truck tires in front and ten ply tractor tires in the rear to carry the load. The complete spraying unit, when full of spray material, weighs nearly five tons.

The water supply truck is usually equipped with a tank formerly used for gasoline or fuel oil delivery. These tanks have baffles and standard pipe thread outlets for attaching the piping to the water pump. Several operators have the pumps plumbed so that they do not need to use the suction hose for filling the sprayer. By turning two valves the pump will draw the water either from the stream supply for filling the truck or from the truck tank for filling the sprayer. The water pump is driven by a power take-off attachment from the truck transmission in most cases, but a few of the operators use auxiliary air-cooled engines with direct drive to their pumps. It is very essential that the water pumping equipment be dependable or the whole spraying operation stops.

After many years of extension teaching on the advantages of a thorough spraying job, our County Agricultural Agents have found the "Custom Potato Spray Ring" the most effective means of getting a time proven practice adopted on a large scale. Efficient spraying has created untold interest in other good potato-growing practices such as better seed, fertilization, weed control and harvesting practices. The grower takes a renewed interest in his crop when he is assured protection from disease and insects.

The small potato grower favors the "Custom Potato Spray Ring" because (1) he does not have to stop haying or cultivating to spray his potatoes; (2) the tractor-mounted sprayer does a far superior job of spraying as compared with the equipment he could afford to own; and (3), the cost of the custom spraying operation will be from one to two dollars less per acre for each application than if he owned and operated his own equipment.

In addition to the spraying operation many operators use the tractor to plow, harrow, plant and dig for members of the ring on a custom basis. This spreads the cost of the tractor over a larger number of hours and keeps the cost of the spraying operation to a minimum. As potato growing machinery becomes more specialized and easily moved on the highway, the small grower will be taking advantage of these more efficient machines to produce potatoes for his cash crop on the general type of farm so common in the state. As a result the consumer can expect a better quality potato from our small New York grower.

SECTIONAL NOTES

CALIFORNIA

The estimates we now hear from various sources on the acreage of potatoes to be planted in 1944 will range from 37,000 to 52,000 acres. It appears to me, however, that 44,000 to 45,000 acres will probably be a maximum figure. The factors that will finally control the total acreage of potatoes in Kern County will be the poundage of nitrogen fertilizer available, the quantity and quality of seed potatoes, the question as to whether the Government should place a floor under the price of potatoes, and the assurance that can be given the growers of this county that the crop can be transported by the railroads. In 1943 the railroads were just able to keep a supply of cars on hand to move the crops. Several days during the peak shipment, it was not certain whether the next day's harvest would be transported, but to my knowledge no actual delays occurred.

Should the so-called big push in the Pacific need rail transportation at the same time that this crop is being harvested, difficulties will probably arise. I am not just sure what the situation is in the five counties north of Kern County in the San Joaquin Valley, but we continue to get reports of heavy increased acreage preparations. We do not know at this time just when the acreage in these northern counties will be harvested. It will probably be immediately following the Kern County harvest. The quality of the crop to be harvested in 1944 will be undoubtedly materially affected by two classes of new growers:—those farmers who have been farming other crops and are now venturing into the potato production field for the first time, and those individuals with outside capital coming into Kern County for the purpose of producing early Irish potatoes. Generally speaking, growers do not produce so good a quality of Irish potatoes the first year as they do in

later years. The quality may also be affected to a certain extent by the quality of seed that will be available. (Jan. 4)—M. A. LINDSAY.

FLORIDA

Low yields are in prospect for the Homestead area of Dade County, Florida, this season, because of a combination of unfavorable weather and the unusually early occurrence of late blight infection.

Potato planting started about the 1st of November, and by the 16th, approximately 4,000 acres were planted. A rainy period occurred from the 16th to the 21st of November, which caused cessation of planting and considerable seed piece decay. Approximately 900 acres were destroyed by seed piece decay, induced by waterlogging of the soil. Our planting operations were not completed until the 10th of December, with the total acreage reaching approximately 6,000. Of this, approximately 1,000 acres are planted to the Pontiac variety, with the remainder planted to Bliss Triumphs.

Late blight was first observed on the 17th of December, and has spread very rapidly. In most cases, blight was present in fields before the plants were large enough to apply copper fungicides and in some instances before all of the plants were above ground. Usually late blight does not appear until the 1st of January or later, when two or more applications of fungicide have already been made. A frost which occurred on the 20th of December, and which caused an estimated 10 per cent loss, was followed by cool weather which held back the development of the potato plants, but favored the spread of blight. On a few farms blight has already killed 90 per cent of the foliage and a crop failure is indicated. Growers using good equipment and doing a thorough job of spraying are apparently holding the disease in check fairly successfully. However, low yields and a high percentage of "B" size tubers will probably prove the rule when harvesting starts in February. (Jan. 7)—GEORGE D. RUEHLE.

MICHIGAN

The movement of table stock has been slow during December, which is always natural during the holiday season. Interest always increases during the first part of January. With stronger demands, it looks very doubtful if Michigan will ship as many cars as government reports would indicate. Michigan is less than 10 per cent ahead of last year on shipments and according to estimate, we should ship 80

per cent additional cars this year. It does not look as if there is enough left to ship this estimated amount.

Our certified seed inquiry is very good. In fact, inquiries and sales are ahead of any season we have ever seen. The crop of seed is about 20 per cent above that of last year, and we believe all certified seed will be sold early at ceiling prices.

Interest on War Approved seed will probably increase as the supply of certified seed becomes exhausted. (Jan. 10)—H. A. REILEY.

NEBRASKA

The movement of Nebraska certified potatoes began in the early part of December. The early seed movement, which goes to the lower Rio Grande Valley, was practically over by Christmas.

With the beginning of the year, the heavy seed movement got under way. At this time, Nebraska certified potatoes are going into Louisiana, Alabama, Mississippi and Florida. The sale of Nebraska Certified seed is below that of last year, because of reduced yields. Contracting was good, and ceiling prices were received until the dry land crop was exhausted. The irrigated crop is substantially sold.

Potato dealers report that the sale of War Approved seed potatoes has been very slow. It has been so low that it is discouraging both to the growers and dealers, and a small amount is being moved into table stock channels. The prices received are only slightly higher than table stock, for comparable grades.

The movement of table stock has been slow for about a month, and despite the fact that Nebraska has a materially shorter crop than in 1942, there is some doubt expressed whether the table stock crop will clean up satisfactorily. (Jan. 7)—MARX KOEHNKE.

NORTH CAROLINA

Recent reports from important producing areas in Eastern North Carolina indicate that growers intend to plant 12 per cent less acreage of commercial early Irish potatoes in 1944 than was harvested in 1943. This will be about 2 per cent more than the 10-year (1933-'42) average, according to the Federal-State Crop Reporting Release of the 10th of January. If growers carry out their intention, this will mean about 35,000 acres will be planted in 1944 as compared with 40,000 in 1943, and a 10-year average of 34,500 acres. These figures are almost in agreement with the goals established, which call for a reduction in the

early commercial-producing areas and a slight increase in the late or mountain area. Many farmers attempted to drop other crops out of production in 1943 and plant potatoes. They now realize their mistake, and we feel rather sure it will not be made again.

A series of five potato meetings have been held in the early commercial sections at which time the whole potato program was discussed with growers. It is felt that these meetings will do much to stabilize the industry, prevent mistakes, and improve practices in both production and marketing.

Red Warba has yielded especially well in Eastern North Carolina, and from 3 to 5 carloads of seed have been ordered and will be planted this year. Two seedlings that were developed in the breeding program, one white and one red, show much promise and may be worthy of introduction. Both are as early as Cobbler. (January 13)—M. E. GARDNER.

OREGON

Considerable White Rose certified seed are now being moved to growers in California. Some Russets are also being sacked and tagged. Our commercial shipments to date total 5,500 cars,—the heaviest shipment in history. Fifty per cent of our crop was shipped by January 1st.

Preliminary indications show that the acreage of certified seed will be increased during the coming year. (Jan. 3)—C. A. HENDERSON.

SOUTH DAKOTA

Growers are now loading certified seed potatoes for shipments to the southern states. Most of this stock is going out on contracts made last fall. The quality of the potatoes shipped is very good and our growers are enthusiastic over the deal this year.

Nearly all the cars are going out under the blue tag grade, but some shipments have been made under red tags; and the third grade, under the green tag, will take care of the potatoes that would not make the other two grades.

The disease reading in the field is the same for all three grades. The only difference being in the grading for shipment. Only one car of War Approved seed has been shipped to date. (Jan. 13)—JOHN NOONAN.

CERTIFIED SEED POTATO CONFERENCE

(Twenty-fifth Annual Meeting of the International Crop Improvement Association, Chicago, Illinois, November 30 and December 1, 1943.)

About sixty persons who are interested in seed potato certification attended the conference which was held in the Roosevelt Room of the Hotel Morrison, the headquarters of the annual meeting of the International Crop Improvement Association.

Twenty states from Maine to California and the Dominion of Canada were represented officially. In nine of the states, which were represented, the certification agencies are now members of the International Crop Improvement Association. Two states that are interested primarily as seed consumers were represented officially. The Office of Price Administration, the Commodity Credit Corporation, the War Food Administration, the Food Distribution Administration and the Extension Service of the United States Department of Agriculture were represented. Only fourteen states in which some seed certification is being done now or in the recent past were not represented. With two exceptions, the volume of seed potato certification in these fourteen states is small.

The conference was entirely informal in accordance with the plan as announced in the notice and invitation. However, every subject on the following program was thoroughly discussed and two full days were used to cover the ground.

Production Goals—Certified Seed Requirements
Discussion leader—A. E. Mercker, F. D. A.—U. S. D. A.
Grades and Standards for Seed Potatoes
Discussion leader—R. R. Pailthorp, F. D. A.—U. S. D. A.
State Laws & Regulations Affecting Seed Potatoes
Discussion leader—W. A. Davidson, U. S. D. A.
Support Prices and AAA Incentive Payments
Discussion leader—A. E. Mercker, F. D. A.—U. S. D. A.
Ceiling Prices for Seed Potatoes
Discussion leader—L. V. Card, F. D. A.—U. S. D. A.
Office of Price Administration—F. C. Hart, John Paschke
Inspection Problems—Field Inspecting, Grade Inspection
Discussion leader—Marx Koehnke, Nebraska
The Storage Situation
Discussion leader—R. C. Hastings, North Dakota

The Transportation Situation
Discussion leader—Paul Findlen, Extension Service, U. S. D. A.
Tuber Indexing and Winter Testing Seed Potatoes in Southern States and in Greenhouse
Discussion leader—F. E. Garrett, Alabama
Research Work Needed—Insects, Diseases, Varieties, Culture
Discussion leader—H. M. Darling, Wisconsin
Educational Work Needed—Promoting Certified Seed
Discussion leader—R. J. Haskell, Extension Service, U. S. D. A.
Plans for an Annual Seed Potato Conference
Discussion leader—Bruce Jones, New York

At the opening of the conference Mr. Jones of New York, chairman of the International Crop Improvement Association committee on seed potato certification, explained the purpose and plans of the conference and suggested that those in attendance should elect a chairman.

The name of H. A. Reiley of Michigan was placed in nomination. There being no other nominations, Mr. Jones called for a vote, and declared Mr. Reiley unanimously elected chairman.

Following the discussion of grades and standards, a committee was appointed by the chairman, as instructed in a formal vote of the group, to work with the special committee of the United States Department of Agriculture and to draw up a standard for War Approved Seed Potatoes for 1944. The committee brought in a recommended standard which was adopted unanimously.

Standards for certified seed potatoes as such were not considered at the conference, but tags for certified seed and war approved seed were considered. As instructed by the group, the chairman appointed a committee to give special attention to this subject. Upon the recommendation of the committee it was voted unanimously to adopt the following colors for tags:

Orange for war approved seed potatoes
Blue for first grade certified seed
Red for second grade certified seed.

The committee, although instructed to consider a uniform wording for all certified and war approved seed potato tags, recommended that this matter be left to the individual states.

During the past year, the International Crop Improvement Association through special committees, has conducted a thorough study of seed certification of the small grains, corn, soybeans, field beans, cotton,

sorghums, vegetables, grasses and small seeded legumes in the United States and Canada. One of the results of this study is greater unification of seed certification work and standards for the crops concerned.

The importance and value of the work of the International Association on seed certification of the several crops studies were recognized and the hope was expressed that similar study might be made on the certification of seed potatoes in the United States and Canada.

In recognition of several very important special problems connected with seed potato inspection and certification, it was voted unanimously to recommend to the incoming chairman of the seed potato certification committee that the appointment of such sub-committees as seem desirable be considered.

At the conclusion of the meeting it was voted unanimously that this seed potato conference was highly successful, and it was requested that a similar conference be arranged for next year. (Jan. 1, 1944)—Bruce P. Jones.

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INFECTION EXPERIMENTS WITH POTATO RING ROT AND THE EFFECT OF SOIL TEMPERATURE ON THE DISEASE

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Observations of potato plants infected with *Phytomonas sepedonica* disclose a wide range in the severity of symptoms varying from a total absence of foliage symptoms to complete destruction. The possibility that this variation is partly caused by the influence of environmental factors upon the symptoms led to the initiation of experiments designed to determine the effect of soil temperature upon infection and development of the disease. These and other experiments conducted in the greenhouse during the winters of 1940-'41 and 1941-'42 provided an opportunity to study the distribution of the bacteria through the plant in relation to the symptoms and to develop more accurate methods of diagnosis. Experiments were also conducted on the physiology of the organism and the effect of various chemical treatments, with particular reference to knife transmission. These studies were discontinued in July 1942 before the entire investigation was completed and some of the results obtained are here presented in the form of a brief summary for the use of other investigators working on this problem. The conclusions presented are based on completed experiments, but additional work will be needed to confirm the results of the soil temperature experiments.

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Summary of Results

1. Effect of Soil Temperatures of 14°, 18°, 22°, 26°, and 30° C. Seed-piece inoculation with a knife contaminated with inoculum from macerated tissue of ring-rot tubers averaged 23 per cent infection. Fifty per cent infection occurred at 14° and 18° C. whereas there was only about 5 per cent infection at the higher temperatures. The development of symptoms was more rapid at 18°, averaging 63 days, than at 14° C. where the average time was 88 days. However, nearly twice as many stolons and tubers were infected at 14° as at 18° C. on the infected plants.

Sprout inoculation by hypodermic injection of sprouts 1 to 2 inches long, with the same inoculum as that used in the cutting-knife inoculations, resulted in much more infection, averaging 73 per cent. There was no significant difference in the amount of infection at 14°, 18°, 22°, and 26° but very little infection occurred at 30° C. In general the foliage symptoms appeared earlier (44 to 60 days) than with the seed-piece inoculations and there was little difference in the time of appearance of symptoms in the plants grown at 18°, 22°, and 26° whereas symptoms appeared more slowly at 14° C. Maximum stolon and tuber infection occurred at 18° with progressively less at 22° and 26° and with no infection of stolons and tubers in the one plant infected at 30° C. The percentage of infection of stolons and tubers was very low at 14° C. in contrast to the results obtained by seed-piece inoculation.

It appears from these experiments that the temperatures most favorable for the potato, 18°-22°, favor the development of ring rot in stems, stolons, and tubers. At these temperatures about 25 to 30 days elapsed from the first appearance of symptoms until the death of the plant. High temperatures decreased infection, particularly with seed-piece inoculation.

2. No correlation was found to exist between the time of appearance of foliage symptoms and the distribution of the bacteria in the plant at harvest time.

3. The bacteria were found in all vegetative parts of infected plants, such as aerial and underground stems, petioles, stolons, tubers and roots; however, the organism was more consistently present in the roots and underground stem than elsewhere in the plant.

4. Infected plants without leaf symptoms and without the bacteria being present in the aerial stems sometimes produced infected stolons and tubers. Conversely, plants with leaf symptoms and with numerous bacteria in the stem sometimes revealed no bacteria or only small numbers of bacteria in the stolons and tubers. However, most

infected plants had foliage symptoms with the bacteria present in the stem. In some instances one stem was found to show severe symptoms and contain many bacteria while another stem from the same seed piece remained healthy.

5. Long stolons were found to be less likely to produce infected tubers than were short ones. The size of the tuber was not correlated with the percentage of tuber infection.

6. The stem was found to be the most reliable portion of the plant from which to obtain smears for microscopic examination. These smears should be taken about one inch below the ground line. All infected plants contained bacteria at this point and the small amount of starch and extraneous material permits a more accurate examination of the stained preparation than when the smear is made from other tissue.

7. The use of inoculum containing equal amounts of pure cultures of *Erwinia carotovora* and *P. sepedonica* decreased the percentage of infection and increased the length of time required for the development of symptoms as compared with inoculum of *P. sepedonica* alone. Inoculum containing both organisms resulted in a greater percentage of tuber infection with visible evidence of rot at the stem-end of the tuber than did pure culture inoculations of *P. sepedonica*. However, soft rots of the pith of the tuber occurred without the presence of the soft-rot organism and while the tuber was still attached to the plant,—without any evident external symptoms in the tuber or stolon.

8. The ultraviolet-light equipment described by Iverson and Kelly (1) and used as recommended by these investigators failed to detect some infected tubers, that by either culturing or staining, were found to contain large numbers of ring-rot organisms.

9. Laboratory tests of bactericides using contaminated metal simulating a knife and determining the results by broth cultures showed that Roccal in a 1-100 concentration was an effective bactericide for the ring-rot organism.

10. The ring-rot organism was found to remain viable for long periods of time without transfer when cultures on agar slants were covered with sterilized mineral oil (2). Continued tests of these cultures have shown some of them to be still viable after 28 months under oil.

Literature Cited

1. Iverson, V. E. and H. C. Kelly. 1940. Control of bacterial ring rot of potatoes with special reference to the ultraviolet-light method for selecting disease-free seed stock. Mont. Agr. Exp. Sta. Bul. 386.
2. Sherf, Arden F. 1943. A method of maintaining *Phytomonas sepedonica* in culture for long periods without transfer. Phytopath. 33:330-332.

POTATO FERTILIZATION AND NUTRITION STUDIES IN 1942[1]

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Results of investigations, most of which were published in 1942, on fertilizers, fertilization, rotations, green manures, cover crops, and soil reaction with reference to the potato are summarized briefly. Some references which have not been abstracted in this review are included in the bibliography with the literature citations for those who desire a fairly complete bibliography on this subject.

Rotations and Green Manures

Chucka and Harrington (37) compared the yields of eight different green-manure crops for potatoes. Sunflowers yielded the largest amount of organic matter followed in order by corn, millet, buckwheat, sudan grass, crimson clover, oats, and soybeans.

In another experiment corn produced about twice as much organic matter as crimson clover. Potato yields following the crimson clover, however, were somewhat higher than those following corn. Yields were also higher where all the fertilizer was applied to potatoes and none to the green-manure crop, than they were where part of the fertilizer was applied to the green-manure crop and the remainder to the potato crop. Potatoes following potatoes yielded lower than potatoes following either of the green-manure crops.

Brown (8) obtained an average of 30 bushels per acre increase in the first season of potatoes following a green-manure crop. In the second season following green manures, there were no increases over potatoes grown every year. The greatest differences between rotated and non-rotated potatoes have been obtained in the driest seasons. Redtop and crimson clover have been followed by high yields of potatoes, whereas soybeans and millet have resulted in lower yields than redtop and crimson clover.

Ware (62) conducted experiments in Alabama on the value of organic matter and irrigation in the production of potatoes. The addition of *Lespedeza sericea* and the plowing under of vetch and cowpeas markedly increased yields above those plots receiving no organic matter.

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With the addition of irrigation water, yields from the organic-matter plots were further increased. Winter barley seeded in August proved to be a very satisfactory cover crop in Southern Ohio (12). Bird (7) states that the most common potato rotation practiced by Plateau growers in Tennessee consists of potatoes, corn, and Lespedeza two years. Crimson clover as a cover crop has proved well suited to the potato rotation.

Fertilizer Practices

Chucka, Hawkins, and Brown (16) demonstrated the importance of crop rotation and of adding organic matter in addition to chemical fertilizers. The effect of varying amounts of nitrogen, phosphoric acid and potash in potato fertilizers was studied over a period of 15 years. As compared with the yield produced by a 4-8-7 standard mixture, leaving out nitrogen reduced the yield by 84 bushels, and leaving out potash reduced the yield 248 bushels. Increasing the amounts of nitrogen, phosphoric acid, and potash over the amounts contained in a 4-8-7 mixture, resulted in a small increase in yield from additions of nitrogen, no increase from additional phosphoric acid, and a rather large increase from additional potash. Of the minor elements thus far only magnesium deficiency has been observed on the plots receiving synthetic salt mixtures. Studies comparing acid and neutral fertilizers were started in 1938. Thus far the acid fertilizers have produced as high yields as the same mixtures made neutral by the addition of either high calcium or dolomitic limestone.

Manurial and other factors that induce deficiency symptoms in potato plants relating to K, phosphates, and Ca, respectively, were observed by Cowie (21) in field experiments. Leaf scorch and the other K-deficiency symptoms on the aerial part of the plant are normally induced by nitrogen-phosphorus treatment and not by nitrogen treatment. The presence of leaf scorch on N plots is correlated with a high level of available phosphates in the soil. By the increase of N in N-P plots the potassium (K) deficiency symptoms of the plants were intensified. An interaction between N and phosphates is the primary factor inducing K-deficiency symptoms in the aerial part of the plants. Blackening of cooked tubers, previously assumed to indicate K deficiency, results from a combination of high N with low K in the soil. Phosphate deficiency is induced by N, and especially by N-K treatments. Phosphate-deficiency symptoms are produced on N plants by low phosphates and low K in the soil. Calcium-deficiency symptoms appeared on poor sandy soils with a pH of 4.5-5.0.

Maine workers (37) compared nine different 8-16-16 formulae with one 4-8-8 formula. The 8-16-16 formulae varied in content of calcium, and in sources of nitrogen and magnesium. The formulae without nitrate nitrogen tended to produce lower yields than formulae with other nitrogen sources, although the differences were not significant. The variations in calcium content and variations in source of magnesium had no measurable effect on potato yields.

Results of studies in Maine (37) indicate that some increases in yield of potatoes may be secured with the use of starter solutions, but that the increase is too small to warrant the extra expense of using these materials.

Smith (50) pointed out the value of using manure efficiently and of growing leguminous green manure crops to supplement the 1943 nitrogen shortage; also the value of organic matter content of soil, correctly balanced fertilizers, quantity of fertilizer needed, method of applying fertilizer and favorable pH values in getting the greatest value from a commercial fertilizer in New York State.

Chucka, Hawkins and Harrington (37) found that approximately a 1-2-2 ratio of nitrogen, phosphoric acid and potash produced the highest yields as an average on three widely separated farms in Maine.

Under fair cultural methods on relatively old land, 1,000 lbs. of a 4-10-4 fertilizer proved most practical on the Cumberland Plateau of Tennessee (7). Under adequate insect and disease control, 2,000 lbs. per acre produced economical returns.

Bushnell (12) states that with early potatoes on sandy loam soil in southern Ohio a 6-8-8 fertilizer at the rate of 1,000 lbs. per acre proved ample for yields of 300 bushels per acre. A somewhat heavier rate of application is suggested if a higher yield is anticipated.

The equivalent of a ton of 5-8-6 fertilizer to the acre has resulted in highest yields in Connecticut (8).

Hibbard (30) states that for Missouri conditions, fertilizer mixtures analyzing 4 to 5 per cent nitrogen, 10 to 16 per cent phosphorus and 4 to 6 per cent potash are most generally advised. If liberal quantities of manure are used, a material carrying only nitrogen and phosphorus is satisfactory. An application of 300 to 600 lbs. of an analysis such as 4-12-4 or 4-16-4 can be used economically.

Burk (11) states that results of tests in Oklahoma for a period of 8 years indicate that 4-12-4 on the heavier soils and 6-12-6 on the lighter soil types could be tentatively recommended. From 400 to 600 lbs. to the acre would likely be the desirable quantity.

Cordner (19) states that potatoes on many soils in Oklahoma

respond best to a fertilizer with a 1-2-1 ratio, such as a 4-8-4, applied in the row at about 600 lbs. per acre. High potash fertilizers have not been proved necessary in Oklahoma.

Bennett (6) stated that responses to fertilizers in Idaho have been variable, some soils responding favorably and others giving no results. All experiments so far in the potato-growing areas have given no response from the addition of potash. There is some indication that small applications of nitrogen and phosphorus will increase yields.

Le Clerg (33) briefly described the fertilization practice and crop rotation in potato production in the Southern States.

Brown (9) presented data to show that potato yields in 171 experiments in 7 states averaged 73 bushels to the acre—more in fertilized than in unfertilized soil.

Teakle, Burvill, and Morgan (54) report that the most profitable potato fertilizer application per acre for the growing conditions in Western Australia is a mixture supplying 200 lbs. of ammonium sulfate $(NH_4)_2SO_4$, 800 lbs. of 22 per cent superphosphate and 100 lbs. potassium sulfate (K_2SO_4). The absorption per ton of fresh tubers, as calculated from the analysis, amounts to 11.6 lbs. of K_2O, 2.73 lbs. of P_2O_5, and 7.4 lbs. of N.

Teakle and Morgan (55) found that on virgin peat soil 800 lbs. of superphosphate were adequate for potatoes, on old potato land 400 lbs. gave optimal yields, while on land that had been under pasture, 1600 lbs. were found necessary for the best yields. From 100 to 200 lbs. of $(NH_4)_2SO_4$ gave improved yields and in one case superphosphate was necessary for a response to $(NH_4)_2SO_4$. In only one case out of three was K_2SO_4 beneficial.

Zhurbitskii (64) cites experiments in various parts of the Soviet Union showing the differential behavior of truck crops to manure and mineral fertilizer. He divides the crops into two groups: (1) cucumbers, carrots and onions respond more favorably to manure treatment in the rotation. (2) cabbage, beets, tomatoes, potatoes, and celery respond more favorably to mineral fertilization. Conditions in the soil which might change, in some measure the classification mentioned, are given and discussed.

Campbell and Pepper (14) described several types of fertilizer experiments that were conducted in 1942 with potatoes in New Jersey.

Lockwood (35) discussed the fertilizer problems from the fertilizer industry viewpoint, particularly with reference to conditions in Pennsylvania.

Phosphorus

White-Stevens (63) compared six sources of phosphorus in the production of potatoes on Long Island with applications of 2,000 lbs. 5-10-5 fertilizer to the acre. The following five sources were equally efficient in providing adequate phosphoric acid: superphosphate, nitrophoska, soft phosphate, potassium metaphosphate, and monocalcium chlorophosphate. Ammophos, on these low reaction soils, was not so suitable as the others.

Brown (8) found that triple superphosphate (48 per cent P_2O_5), calcium dihydrogen phosphate, fused phosphate rock and calcium metaphosphate were about equally effective as sources of phosphorus for potatoes. Also, good results were obtained with potassium metaphosphate (P_2O_5, 57 per cent; and K_2O, 35 per cent). Potatoes fertilized with $CaHPO_4$ showed mild symptoms of P deficiency and gave slightly smaller yields. Very finely ground, raw phosphate rock was not sufficiently available for a rapid vine growth and a high yield of tubers.

Houghland *et al* (31) compared potato fertilizers containing a carrier of P_2O_5 in the form of one of the new phosphatic materials, calcined phosphate, fused phosphate rock, monocalcium chlorophosphate, $CaHPO_4$, $Ca(PO_3)_2$ and KPO_3 with mixtures containing ordinary and triple superphosphate in Maine, New Jersey and Pennsylvania over periods of 2 to 4 years. Results of these experiments indicate that none of the materials as used was injurious to potatoes. Yields were not always equal to those with ordinary superphosphate, but the responses were regarded as satisfactory. The potato crop, grown on acid soils, was apparently able to utilize P readily from the new phosphatic materials.

Brown *et al* (10) presented results of field experiments in Maine, New Jersey, Pennsylvania and Virginia, showing that superphosphates made respectively with sludge sulfuric acid (H_2SO_4) from the refining of petroleum products and with spent H_2SO_4 from the manufacture of high-octane gasoline by the alkylation process were as efficient as superphosphate made with clear H_2SO_4, as sources of phosphorus for potatoes.

Chernayin (15) showed that the effect of mixtures of phosphorite meal and superphosphate was equal to or greater than that of the amount of P_2O_5 in the form of superphosphate contained in them. Relationships were established between the action of the mixture and the biological properties of the plants, especially the course of the absorption of nutritive substances during the various stages of growth. The mixing of phosphorite meal and superphosphate for the purpose of neutralization

and improvement of the physical properties of the superphosphate can be recommended for all plants and all soils. The use of the mixture or the separate use of superphosphate and phosphorite meal (60-70 per cent of the latter) is recommended for growing flax, sugar beets, potatoes, winter rye and possibly spring wheat on podzolic soils, gray woodland soils and degraded and strongly alkaline chernozems. The best results with the mixtures are obtained when the phosphate fertilizer is applied in the fall. When it is used in the spring the proportion of superphosphate in the mixture must be increased.

Ware, Brown and Yates (61) found in Alabama that the effects of phosphorus applications are carried over for a considerable number of years as indicated by crop yields and chemical analysis of the soil. The available phosphorus as determined by chemical tests and by crop yields becomes quite low for all rates within 4 to 7 years after applications end. The amount of previous applications does not affect yields to any appreciable extent where high applications are being made during later years. High applications over a 4-year period are of value to succeeding crops where low applications of phosphorus are being made during later years.

Studies in Maine (37) indicate that more phosphoric acid is being used in potato fertilizers than is necessary to obtain maximum yields.

Bushnell (13) found no differences in yields of potatoes in 1941 on Chenango sandy loam soil in Ohio from applications of 1500 pounds per acre of 6-8-8, 6-4-8 and 6-0-8 fertilizers. He suggests that where the test for available phosphorus shows more than 200 pounds per acre that a field trial be conducted comparing standard fertilizers with one containing 40 pounds P_2O_5 per acre. If the field trial confirms the chemical test, Bushnell recommends 1000 pounds 8-4-12 to the acre for potatoes in Ohio.

Bear and Toth (3) pointed out that the continuous use of large amounts of soluble phosphates on a soil results in marked changes in the physicochemical properties of that soil. Among these changes are an increase in exchange capacity and a lowering of the pH at which iron and aluminum come into solution. Any increase in exchange capacity results in a greater retention of the nutrient cations which will have been applied in combination or in association with the phosphate. These facts help explain why it is possible to continue to produce high yields of potatoes on soils which must be maintained at pH values approximating 5.2 for the control of scab.

Potassium

Asdonk and Jacob (2) found in a survey of 3678 experiments an average increase was obtained of 19.2 kilograms of tubers or 3.5 kilograms of starch per 1 kilogram of K_2O. Additions of 80 kilograms of K_2O gave an average increase in yield of 1730 kilograms of tubers; fertilizing with 120 kilograms of K_2O gave an increase of 2130 kilograms, 160 kilograms of K_2O gave an average increase of 2800 kilograms of tubers. Of the various K forms Patenkali and K_2SO_4 proved preferable to 40 and 50 per cent K_2O fertilizers as far as tuber yields and still more as far as starch content are concerned. The last produced an average of +1.9 kilograms per 1 kilogram of K_2O, whereas K_2SO_4 produced +4.2 kilograms. No correlation could be found between the K content of the soil and the increased yield. The pH had no effect on the yield increase. The yield increases were greater without stable manure than when cultivated in stable manure. In soils depleted of K by previous crops the response to K fertilizer was stronger. No relation was found between the effect of K and the kind of potatoes grown. The timely use of K is important for a good starch yield.

Cowie (22) shows that compared with K_2SO_4, the average decrease in yield of tubers per acre from 100 lbs. of KCl is 200 lbs. without dung and 120 lbs. with dung. The mean reduction by an equivalent dressing of kainite is 1160 lbs. without dung and 720 lbs. with dung. The use of dung ameliorates the harmful effect of chlorine on yield. Both KCl and kainite depressed the dry-matter content of the tubers in each experiment. The mean reduction is 1.41 per cent from KCl and 2.74 per cent from kainite. Dung does not appreciably reduce the effect of Cl on the dry matter of tubers. The percentage of starch in the dry matter is depressed by chloride-containing potash fertilizers. Kainite leads under certain conditions to the production of potatoes with a soapy texture and a tendency to blacken after boiling.

Results of experiments in Maine (37) show that fertilizers with 10 per cent potash produced slightly higher yields than did the fertilizers with 8 per cent potash. Raising the potash above 10 per cent did not increase potato yields. Fertilizers with sulfate of potash and with combination sources of potash produced somewhat higher yields than did fertilizers with muriate of potash as the only source of potash.

Thun (57) noted that on neutral soils the chloride-containing fertilizers and on acid soils potash-magesia give better tuber yields. In reference to the starch yield the sulfate-containing fertilizers show the best effect. On the neutral soils K_2SO_4, and on acid soils potash-magnesia, are superior.

Nemec (43) found that strong reduction in the starch content of potatoes fertilized with kainite and 40 per cent K fertilizers appears with heavy precipitation. The decrease is heightened by large chloride content and a strongly acid reaction of the soil. Fertilizing with Cl-free K fertilizers generally increases the starch content.

Fertilizer Placement

Chucka, Hawkins and Harrington (37) applied 8-16-20 and 8-12-20 at rates of 1000 and 1500 pounds per acre in equal depth bands compared with hi-lo bands. All methods of placement yielded approximately the same. The 8-12-20 fertilizer produced as high yields as the 8-16-20 at both rates of application and in all placement methods.

Smith (52) compared the yields from three methods of fertilizer placement, two rates of fertilizer application, two distances of spacing of seed pieces, two sizes of seed pieces and two varieties of potatoes. With applications of 2000 pounds 4-8-8 fertilizer to the acre, the best method of application was the high-low method. With both the Sebago and Smooth Rural varieties at 11-inch spacing, highest yields are obtained from equal depth band and high-low band placements; at 14-inch spacing, highest yields resulted from high-low band placement. With 1-1/4 ounce seed pieces at both rates of fertilizer application, the best placement of fertilizer appears to be the high-low band method. With high-low band method, yields were consistently high regardless of the size of seed pieces or distance of spacing. At 11-inch spacing, yields from equal depth method of placement also were high. Yields from the method of placement of one-half broadcast, plowed under, one-half bands were consistently low at both spacings and both sizes of seed pieces.

Band application of fertilizer was slightly more effective than common row application mixed with the bull tongue in Tennessee (7).

Greenhouse experiments by Dunn (27) showed that where the potato seed piece was not in actual contact with the fertilizer, no injury resulted. Actual contact of the seed with the fertilizer caused distinct plant injury.

Minor Elements

Ellenby (28) found that increased weight of tubers and increased size of plant were obtained when rows of potatoes in soil badly infested with the eelworm (*Heterodera schachtii*) were treated with traces of

boron, zinc, cobalt, manganese and nickel salts in diluted solutions. This indicates that the eelworm is not the sole cause of disease known as potato sickness, but nutritional deficiency is an important factor.

Applications of zinc sulfate, manganese sulfate, copper sulfate, and borax have had no measurable effect on potato yields on the Cumberland Plateau of Tennessee (7).

No minor element deficiencies for potatoes have been detected in Connecticut (8).

Dennis and Dennis (25) present a very complete review on boron and plant life.

Soil Reaction and Liming

Albrecht and Schroeder (1) conducted studies with spinach and potatoes and showed far greater mobilization of the nutrients into the crop when the soil was acid than when it was neutral. In some cases, this was reflected in the form of increased crop yields, but in all cases it was evident in the form of increased concentration of many of the different elements in the plant tissue. Of the possible cations taken by plants, calcium, magnesium, strontium and manganese were moved into the spinach crop in greater amounts and greater concentrations in the presence of significant hydrogen ion concentration than in the soil that was nearly neutral. The utilization of K and P by the crop was not widely different according to the presence or absence of H ions, and both the totals and the concentrations suggested precipitation-peptization behavior according to the amounts of exchangeable calcium in the soil.

Schroeder and Albrecht (46) show that tops of potato plants contain large quantities of Ca, whereas K is high in the tubers. Yields of both potato tubers and potato tops in relation to the levels of exchangeable Ca and K were investigated. Importance is attached to the relation of Ca to K while other nutrients are held constant. Soil acidity as a means of reducing the incidence of potato scab is apparently effective because of the increased mobilization of certain cationic plant nutrients by the presence of the H ion.

Cook and Nugent (17) concluded, from experiments conducted in Virginia, that the amount of scab is closely correlated with soil reaction and is only indirectly correlated with the fertilizer reaction or calcium content of the fertilizer to the extent that the fertilizer may change the soil reaction. It is also concluded that calcium itself has no effect in the development of scab and that calcium compounds affect it only to the extent that they may change the soil reaction.

Cook and Houghland (18) stated that when they were used continuously for 7 years, the same fertilizers in which the potential acidity was, respectively, completely neutralized and one-third neutralized ultimately affected the occurrence and amount of potato scab, principally through their effect on the degree of acidity of the soil. The incidence of scab and the pH value of the soil were highest with the completely neutralized fertilizer.

Corum (20) presented data on the effect of pH on the initiation of growth of potato tubers. A bimodal curve of growth was obtained. For the sprouting of the potato tubers, the minimum in the curve is at pH 7.0. Hydrogen ions are relatively more toxic to potato tissue than to the spores of *Rhizopus suinus;* hydroxyl ions are relatively more toxic to the spores *Rhizopus suinus* than to the potato tissue. This effect of pH on the initiation of growth is considered to be directly related to the effect of H-ion concentration on the hydration of the biocolloids of the protoplasm of the plant tissues concerned.

On light strongly acid soils in Brandis, Selke (48) found dolomitic gray limestone (26.43 per cent CaO, 16.34 per cent MgO) was superior to white limestone when used on rye and potatoes. On these soils the dolomitic limestone is suited for the rapid and lasting correction of magnesium deficiency. Favorable results obtained with concurrent applications of $MgSO_4$ $7H_2O$ and limestone indicated that the better action of the dolomitic limestone was not due solely to its effect on soil acidity but also to its nutrient action. Favorable results on potatoes with dolomitic limestone are assumed to be due to the effect of the siliceous residue of this material (12.85 per cent insol.). In laboratory experiments, dolomitic limestone was slower in its neutralizing action than limestone. Limestone has less effect on soil reaction during the first year than in the next two years. Limestone applications, however, sharply diminished the exchange acidity during the first year. For rapid change in soil reaction burnt lime must be used in the amount indicated by titration of the acidity to avoid overliming. Magnesium sulphate had no significant effect on the soil acidity but it did appear, indirectly, to affect the neutralizing action of the limestones. Calcined lime and calcined dolomitic lime on a slightly acid, heavy-weathered soil, gave about the same results. Compared with limestone, calcined limestone had the greater effect on the soil acidity the first year. The Aspergillus method of Niklas and Toursel gave results for the Mg status of the soils in satisfactory agreement with the field experiments carried out at Brandis.

Sveshnikov (53) showed that the unfavorable effect of large doses

of lime was maximum at low moisture contents of the soil during the period of the formation of tubers and during the initial stages of their development. Normal moisure content during the whole vegetation period somewhat alleviated the unfavorable effect of lime, but did not overcome it. The favorable effect of boron (2 mg. of H_3BO_3 per kg. of soil) was most pronounced at normal moisture contents of the soil. Addition of compost and K_2CO_3 simultaneously with lime overcame the unfavorable effect of lime. The addition of KCl increased the unfavorable effect. The unfavorable effect of lime on potatoes is connected with the manifestation of an antagonism between Ca and K.

Absorption of Nutrients

Hawkins (37) states that potato plants capable of producing upwards of 400 bushels per acre, absorb about 120 to 160 pounds of nitrogen, 25 to 30 pounds of phosphoric acid, 200 to 250 pounds of potash, 60 pounds of calcium oxide, 30 pounds of magnesium oxide and about 10 to 12 pounds of sulphur per acre of potatoes. The Green Mountain variety absorbed about 70 per cent of its total consumption of plant nutrients during the season between 50 and 80 days after planting. The earlier varieties, Cobbler and Chippewa, usually emerge and make more rapid growth early in the season than do the later-maturing varieties, and the period of more rapid absorption of nutrients occurred with these two varieties about one week earlier than for the Green Mountain variety.

Hawkins (29) reports that the quantities of major plant-food elements absorbed per acre by plants (tops, tubers and most of the roots) of the Cobbler, Chippewa, Green Mountain and Smooth Rural varieties of potatoes in the season of 1939 were: N, 102.6, 103.1, 141.4, 128.5; P_2O_5 21.4, 23.3, 27.1, 24.5; K_2O, 172.1, 163.6, 207.1, 211.4; MgO, 18.7, 26.6, 30.5, 30.5; CaO, 44.9, 39.3, 54.6, 59.1; and sulphur (S) 10.6, 10.6, 12.2, 10.7, pounds respectively. The Mg content of the tops and roots of the Cobbler variety was considerably less than that of the other varieties, but there was comparatively little difference between varieties in the Mg content of the tubers. During the first 50 days after planting, the Green Mountain variety absorbed 9 per cent of the total major nutrient elements while making 3 per cent of the season's growth (110 days), and 69 per cent was absorbed from the 50th to the 80th day. The absorption of nutrients by this variety during the first 50 days and during the next 30 days respectively, was: N, 15.8, 85.6; P_2O_5, 3.2, 15.9; K_2O, 14.9, 163.9; MgO, 2.0, 18.3; CaO, 3.7, 36.4; and S.

1.0, 6.7 pounds per acre. The later varieties (Green Mountain and Smooth Rural) each absorbed about 100 pounds more total major nutrient elements during the season than did the earlier varieties (Cobbler and Chippewa). The later varieties absorbed considerable more N, K, Ca and, as compared with the Cobbler variety, particularly more Mg. The Cobbler variety absorbed 22 per cent of its N requirements by the 50th day as compared with 8 per cent for the Rural variety. By the 70th day, Cobblers had absorbed 86 per cent of the N absorbed during the season as compared to 52 per cent for the Rural and 56 per cent for the Green Mountain varieties.

Turchin (58) noted that a potash deficiency produces more marked symptoms in those plants which have received their N as ammonia N than in those which have received it in nitrate form. In the case of potatoes receiving their N in ammonia form an insufficient supply of K causes a reduction in yield, and accumulation of NH_3 in the underground portions of the plant, an increase in the content of total N and that of amino acids in the tuber and a sharp reduction in starch content. These effects can be eliminated by post fertilization with K. An early use of K is, however, more advantageous than later fertilizing with it after a K deficiency has developed. In sand cultures, where no fixation of P by the soil is possible, the P requirements of plants are higher with nitrate N than with ammonia N. An excess of phosphate in sand cultures with NH_3 fertilization frequently has an injurious effect on growth, especialy when there is a K deficiency. Conversely, when phosphate is present in slight amounts in the growth medium, ammonia N improves the phosphate nutrition of the plant. In soils containing only slight amounts of free sesquioxides, as chernozems, the phosphate requirements of the plant are greater when nitrate fertilizer is used than with NH_3 fertilizer. In the case of podzolic soils with a high content of sesquioxides the use of physiologically acid NH_4 salts reduces the assimilability of the phosphoric acid. This reduction can be compensated by the simultaneous use of equivalent amounts of $CaCO_3$.

Leaf Analysis

Beauchamp (5) found that increments of potassium in the fertilizer caused marked increases in yield but increments of nitrogen and phosphorus did not. Leaf samples were taken 52 days after planting, and harvesting was done 16 days after sampling. The field yields of potatoes showed a very good correlation with the total percentage of plant nutrients found in the alcohol extract of the leaves. Increasing

the K in the fertilizer resulted in an increase in its percentage in the alcohol leaf extract and, in turn, a higher yield. No-K plots showed a higher content of K in the leaf extract than did the check plots, an indication that the addition of N and P alone stimulated the plant to absorb more potash from the soil. The percentage of P in the alcohol leaf extract was not correlated with its amount in the fertilizer. On the other hand, it showed a marked parallelism with the amount of K in the alcohol-soluble portion of the leaves. The N in the leaf extraction did not present any correlation with the content of K in the fertilizer. The percentages of both calcium and magnesium in the leaf extracts showed an inverse relation to that of K. The percentage of total nutrients in the mineral portion of the leaf extract ($K_2O + P_2O_5 + N + Ca + Mg$) varied directly with the fertilizer treatment.

Beauchamp (4), working with the Irish Cobbler variety in Cuba, found that 1500 pounds per acre of 6-8-10, 8-10-15, 10-8-10, and 10-8-15 yielded about the same; 8-10-0 and 10-8-0 yielded lower and no fertilizer treatment resulted in still lower yields. The analysis of the alcoholic leaf extract of plants grown under the above treatments showed direct relationship between the amounts of nitrogen, phosphorus and potash in the fertilizer, the percentages of these elements in the alcoholic leaf extract and the resulting yields. The same relationship existed when the individual contents of these elements in the entire leaves were correlated with the fertilizer treatments on the one hand and the resulting yields on the other. He states that the analysis of the entire leaves of potatoes, as well as that of the alcoholic leaf extract, may be used as indices of soil fertility deficiencies, or as indicators of the nutrition of the crop.

Lundegardh (36) states that leaf analysis is based on the functioning assimilating leaves as the central "laboratories of nutrition." If samples of the leaves of cereals, potatoes and clover are collected at the flowering stage, the percentage of N, K, Ca and P_2O_5 in the dried material gives an expression of the available amounts of these nutrients in the soil. There is an approximate inverse relation between the concentration of K, N or P in the leaves and the increase in yield after treatment of the soil with the corresponding element. Leaf analysis also shows the effect of the interaction of the nutrients on their availability. It is of some value in teaching the farmer how to economize with mineral fertilizers and how to use them in the right proportions.

Chemical Composition and Cooking Quality

Leichsenring and Donelson (34) present data to show that phosphate, phosphate-potash and N-phosphate-potash treatment had no in-

fluence on the Ca, P and Fe content of the pared potatoes, with the exceptions of the P values from the plots to which P alone had been added. These showed a mean increase of 10.4 per cent as compared with the untreated plots. A decrease in the calcium values of the potatoes resulted from the iron sulfate treatment. The mean decrease noted was 4.3 per cent. The potatoes from the sulfate-treated plots contained a significantly smaller amount of iron than did those from the plots to which no iron sulfate had been applied. A positive correlation was observed between the P and Fe values for the potatoes grown on the iron sulfate-treated plots as well as those from the plots to which no iron sulfate had been added. Ca and Fe values for the potatoes from the untreated plots were positively correlated, as were also Ca and P; but no significant relationship was observed between these values for the potatoes from the plots treated with iron sulfate. Paring potatoes resulted in losses in the total Ca and Fe of the vegetable, 24 and 10.5 per cent, respectively; this indicates that these elements are more highly concentrated in the skin and cortical layer. The P is concentrated in the medulla of the tuber since higher values, 6.4 per cent were obtained for pared than for the unpared samples.

Maiwald (38) reports that potatoes grown on a soil supplying their natural requirements have the highest vitamin C content, but sometimes the vitamin occurs in considerable quantity even in plants attacked by virus disease and in a state of disintegration. Solanine, starch, protein and ash constituents were also determined. Extensive storage experiments showed that even extreme fertilizer applications had no effect on the keeping quality. The darkening of potato tissue after cutting is primarily a variety characteristic, but in those varieties which darken slowly it may be influenced by fertilization.

Experiments were made by Pallmann and Schindler (44) with "Up to date" and "Alma" potatoes. Fertilizing (particularly high N and K_2O doses) did not have an effect on the solanine content of ripe potatoes, but did affect the solanine content of young potato tubers.

Drew and Deasy (26) found that in general, the yield of tubers, percentages of starch and yield of starch were not materially influenced by increasing the amounts of N, P_2O_5 and K_2O over those contained in the standard 1:4:1 mixture of artificial fertilizers. With abnormal climatic conditions such as high temperatures and low rainfall, as obtained in the early part of the 1939 potato-growing season, the addition of K, and more particularly of N and K, to the standard mixture caused an economic increase in the yield of potatoes but did not significantly affect the percentage of starch in the tubers. The percentage of starch in the

tubers was significantly increased by substituting K_2SO_4 for KCl in the mixture; this practice was economically sound when the potatoes were sold for industrial purposes on a starch-content basis, but not when they were sold on a flat-rate basis.

Vinogradskii (59) in field experiments on argillaceous soils, found that chalk (2400 lbs. per acre) on N-P-K base increases the yield of "Voitman" potatoes, but decreases the percentage content of starch in the tubers. Chalk on manure-mineral fertilizer (N-P-K) base increases the yield without decreasing the starch content. Liming in conjunction with $MgSO_4$ (40 lbs. per acre) increases both the yield of the tubers and their starch content. The application of nepheline and boron increases both the yield and the starch content of potatoes. Glaserite, as a source of K_2SO_4, in soil dressing on manure or N-P-K base, in contrast to the 40 per cent K salt, increases the starch content and the yield of potatoes if KCl is used in the fertilizer base.

Smith and Nash (51) made three plantings and three harvests of tubers from each of the following fertilizer treatments applied at the rate of 1000 lbs. to the acre: no fertilizer, 5-10-0, 5-10-5, 5-10-10, 0-10-10, 10-10-10, 5-0-10, 5-20-10, 5-10-10 plus three side-dressings of 2 per cent nitrogen, 5-10-10 plus three side-dressings of 2 per cent potash. Tubers from unfertilized plots and from plots fertilized with 5-10-0 averaged higher in specific gravity than those from any of the other treatments. Tubers from the 5-0-10 plot were lowest in average specific gravity. Tubers from plots receiving 5-10-10 fertilizer and three side dressings of 2 per cent potash or 2 per cent nitrogen were also slightly lower than those of most of the other treatments. Similar results as to percentage dry weight of tubers were obtained. The ratings on texture of the boiled tubers correlated very closely with the specific gravity and dry weight of the tubers.

Practically no differences were noted in extent or intensity of blackening of the boiled tubers at the first harvest between the fertilizer treatments. However, at the second and third harvests, some differences were noted between the fertilizer treatments which resulted in advanced or retarded maturity. Those treatments which hastened maturity usually produced tubers which darkened less than those which retarded maturity. These differences in darkening were caused by differences in temperatures prevailing during the latter part of the growing period for each lot.

McIntosh (41) contends that apart from the actual cooking process, the major factors influencing cooking quality in order of importance are variety, climate, soil and fertilizer. Varieties having a

moderate to high starch content usually exhibit good cooking qualities. The use of fertilizers low in K and excessively high in N favors the production of poor-quality tubers.

Studies in Maine (37) show that potatoes from plots fertilized with "pure chemicals" rank at the top in both cooking quality and starch content. The "pure chemical" fertilizer was made up of potassium nitrate, mono ammonium phosphate and urea, there being no chlorine or fluorine in the mixture.

Diseases

Studies in Maine (37) show that fertilizers containing muriate as a source of potash tended to produce potatoes with a higher net necrosis and stem-end browning reading than did those fertilizers with potash from a sulfate source. Where the potash was derived wholly from the muriate, the percentage of net necrosis and of stem-end browning increased as the potash in the fertilizer ratio was increased. It appears to be the chlorine in the fertilizer that is the disturbing factor. Potatoes from plots fertilized with ammonium chloride as a source of nitrogen had a higher per cent net necrosis and stem-end browning than those with sodium nitrate or ammonium sulfate. There is some indication also that leafroll infection (net necrosis) increases as the amount of phosphorus in the fertilizer increases. Fertilizers containing no chlorine have resulted in less stem-end browning than those with chlorine. Stem-end browning increased as the rate of application of 4-8-8 fertilizer was increased from 0 to 3000 pounds to the acre.

Tereshchenko (56) states that an excess of N with an early dry season followed by heavy rains causes a secondary growth of tops. These are subject to virus diseases. Leaf curling does not occur on old plants. There seems to be no definite relation between various grades of fertilizer, except for those with an excess of N, and virus diseases. Under adverse (dry) weather conditions, plants receiving manure with P-K salts seem to be less subject to virus diseases.

Sanford (45) describes "Apical leaf Speck" suggesting it as the name for a malady caused by soil factors that favor faulty nutrition of the plant.

Erosion

Neal (42) reported the amounts of organic matter, phosphorus, potassium and calcium removed in the eroded material from a Collington sandy loam soil in New Jersey. The eroded material averaged 4

times the organic matter, 1.5 times the phosphorus, 1.4 times the potassium and 2.3 times the calcium contained in the soil from which the erosion occurred. Losses of phosphorus, potassium and calcium are reduced by additions of cover crops, manure and a combination of both. On areas where the surface soil varied from 3 to 6 inches in depth, the yield of potatoes was 13 per cent higher than from areas having less than 3 inches of surface soil. Records from one year's data show a 36 per cent increase in yield for areas having more than 6 inches of surface soil, as compared with areas having less than 3 inches of the surface layer remaining in place.

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SECTIONAL NOTES

ALABAMA

A small acreage was planted in South Alabama during the last week of January, and by the first week of February our growers had planted a very large acreage. Both the weather and the soil conditions have been very favorable. Present indications point to a 25 per cent increase in commercial acreage over 1943. An acreage of 23,000 to 24,000 is expected in 1944 in the three counties of Baldwin, Mobile, and Escambia. Our seed supplies seem adequate, and the seed are arriving in better than average condition.

The Bliss Triumph continues to be the leading variety with a trend toward larger acreage of other varieties,—including the Sebago, Katahdins, and White Rose.

There is a shortage of labor, although it is expected that the acreage now planned will be planted without undue difficulties. (Feb. 9)—L. M. Ware.

CALIFORNIA

Our shippers and receivers are greatly concerned as to the effect of ICC Service Order 180 (new demurrage rates) and ICC Order 181 (restriction of diversion privileges from three to two).

The Government tells us we have the largest potato holdings ever known in the United States. All interested parties hope that these restrictions will not seriously interfere with the proper distribution and consumption of this extremely valuable and greatly needed potato crop.

Our western shippers and distributors have asked ICC to delay the effective date of these New Service Orders at least until the old crop has been moved.

As this record-breaking crop was produced in response to the Government's insistence, this seems as if it were a reasonable request. (Feb. 11)—Ernest Marx.

Various estimates have been made by several individuals. Last evening the Agricultural Commissioner, who is now in the process of getting his survey, reported at a meeting, that, from all indications there would be in the neighborhood of 50,000 acres of potatoes on the floor of the valley in Kern County for 1944. They will complete their survey in approximately ten days. This does not include the mountain acreage

which will undoubtedly be approximately 3,000 acres. (Feb. 11)—M. A. LINDSAY.

LOUISIANA

Our Irish potato crop has been greatly delayed in planting, because of the continuous heavy rains. There has been some planting, however, —as high as 20 per cent in some sections. The increase in acreage still apparently varies from 8 to 10 per cent. (Feb. 14)—P. T. ECTON.

MICHIGAN

The table stock market in Michigan is slow and the trading is light. Although we have gained on our shipments as compared with those of a year ago, in the early part of the season, shipments dropped off in December and January to a point that we are now actually below last year's shipments.

Growers are in a very unsettled frame of mind. Our table stock is selling below the support price. If this should continue any length of time, our growers will lose faith in any future program.

Our seed sales are ahead of any season we have known in a long time. The supply of certified seed is nearly booked up, and the demand for War Approved Seed is very good. If I were to make a guess, I would say that there will be a scramble for good seed before planting is completed. (Feb. 14)—H. A. REILEY.

NEBRASKA

Shipments of seed potatoes from Nebraska have been moving slowly during the month of January. This is an unusual condition, as the month of January usually sees the heaviest movement for the entire season.

A number of factors have been responsible for the erratic movement of seed potatoes. Railroad car shortages have developed frequently, though for only a few days. As a whole, weather has favored loadings, the weather being quite mild until the latter part of the month, when there was a general heavy snow that blocked all country roads.

The principal delay was occasioned by difficulties on the receiving end. Poor weather conditions for planting always influence the speed with which our potatoes are ordered out. This poor condition prevailed most of the time.

The certified potato crop would have been entirely cleaned up by

this time, had it not been for the conditions described. A number of certified growers found that their potatoes graded a higher percentage of No. 1's than was originally indicated. This has resulted in a slightly larger crop than was earlier estimated. Recently our sales have been slow,—the slowness being caused by the erratic southern conditions. The small quantity remaining should be disposed of without any difficulty.

War Approved seed potatoes have been sold to an increasing extent during the month of January. Prior to that time there was very little interest, and a moderate amount of this stock was going into table stock channels. Unless the situation changes radically, the majority of War Approved seed will not go into seed channels. Table stock potatoes have moved slowly. The poorer quality grades were usually a drag on the market.

The planting intentions for certified seed potatoes are for a slight increase in 1944. The increased acreage of 1943 compared with the previous season failed to give an increased yield because of the poor season. The increase in certified potatoes is viewed as a favorable trend, reversing a tendency to decrease acreage that had begun with the 1940 crop.

The Nebraska growers will still be substantially below the high point of the 1940 season, unless there is a material step-up of interest between now and planting time. Foundation seed stocks are bringing good premiums, and are rapidly being sold out. It is far too early to estimate what our planting conditions will be like for this coming season. (Feb. 1)—Marx Koehnke.

OREGON

Our potato shipments are still very heavy. The total shipments to the 1st of February were approximately 7,000 cars. Our total crop was generally estimated at 10,000 cars. Heavy shipments of certified seed have taken place for the past 60 days. The demand for good seed is excellent,—particularly certified seed. The 1944 food sign-up, now under way, indicates that the potato acreage for 1944 will be about the same as that planted in 1943.

The availability of good seed, fertilizer, equipment, and prospective man power during growing and harvest season are the most important factors that are being considered by growers at present. (Feb. 7)—C. A. Henderson.

SOUTH CAROLINA

The acreage of potatoes in this state will probably be slightly less

than in 1943. Many large growers have reduced their acreage by 25 to 40 per cent of last year. An estimate of the percentage of the total commercial acreage that was planted in 1943 and 1944, together with the various varieties follow:

	1943	1944
Irish Cobbler	65	35
Katahdin	15	35
Pontiac	7	17
Bliss Triumph	6	6
Sebago	3	5
Others	4	2

Thus, it is evident that the acreage of Katahdin and Pontiac is increasing, whereas that of Irish Cobbler is decreasing.

Most of our potatoes were planted between the 1st and 10th of February, during which period favorable weather prevailed. In general, the seed potatoes were received in good condition this season. Soft rot in a few carlots caused some damage. In a few cars of War Approved seed from Michigan, a very high percentage of the tubers was scab-infested. In some bags not a scab-free tuber could be found. Who would want to pay $4.75 per cwt. for such seed? (Feb. 11)—C. N. Clayton.

CERTIFIED SEED POTATO CONFERENCE

(Twenty-fifth Annual Meeting of the International Crop Improvement Association, Chicago, Illinois, November 30 and December 1 and 2, 1943).

A brief report of the conference, including the list of subjects discussed, was published in the American Potato Journal for January. The following summaries have been prepared by the discussion leaders of the subjects covered.

1943 Seed Potato Inspection Problems

The consensus of opinion of seed certification officials present was that the chief inspection problem for the past year, and for the coming season, was the shortage of man power. No state reported that it was able to make the inspections as it had previously done, and several officials stated that the use of labor had to be economized and many certification practices eliminated. An additional burden was placed on the inspection forces, because of the introduction of a new class of seed potatoes known as War Approved seed.

In the discussion from the floor, and in the hallways, it appeared that transportation difficulties had been fairly well worked out. In some states, it was not possible to secure enough gasoline to make extensive southern trips, however,—most states had apparently eliminated such trips from their agenda.

It was brought out that the quality of certified seed potatoes, judging by the percentage of diseases found, was being maintained, practically at pre-war levels. Some officials expressed the opinion that an effort should be made to introduce and maintain seed improvement programs. The seed improvement programs consisting principally of producing foundation seed stocks, were thought to be vital elements of the certification programs. By this means the quality of certified seed could be maintained with a minimum of effort on the part of the grower. In view of labor difficulties all along the line, which would prevent roguing of fields by the farmer, such a program was thought to be the key to maintaining a good basc certified seed program for the duration.

It was suggested by an official from the United States Department of Agriculture, that women be trained for field inspection work. Considerable doubt was expressed that this could be done, since it was pointed out that a person had to be trained two or three years, to be reasonably competent. Since many states have followed the practice of using young college men during their vacation periods, and gradually working them into the program, the call of the armed forces has been especially serious. In most states, the loss of men to the armed services was extensive, and disrupted seed certification programs seriously. A number of states are obtaining assistance from other organizations during the summer, by employing men during their vacation periods, or slack seasons on other business. These include men employed in agricultural colleges, such as pathologists, horticulturists, extension men, Smith-Hughes instructors, and in some cases, botany instructors in high schools. By employing such individuals, the inspection work of the past year was accomplished. (MARX KOEHNKE).

THE 1943-'44 SEED POTATO STORAGE SITUATION

Potato growers throughout the nation answered the government's call for increased production in a remarkable manner last season. The result was the largest potato crop in history.

The large crop presented a storage problem,—especially in the northern producing sections. Part of the problem was solved by urging consumers and handlers to stock their needs for the immediate future

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RECENT TESTS OF MATERIALS FOR POTATO SPRAYING IN PENNSYLVANIA[1]

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Several investigators in recent years have studied the possibilities of using fixed copper compounds other than Bordeaux mixture for potato spraying. Sleesman and Wilson (2) have reviewed much of the recent literature and added the results of several years work of their own as it applies to muck-grown Irish cobblers. They have shown that certain fixed copper compounds gave yields comparable to Bordeaux, and that these were more effective when applied as dusts rather than as sprays. Whipple and Allen (3) and Bonde (1) also have shown certain fixed coppers to be the equivalent of Bordeaux. In spite of the fact that potato spraying, as a well established practice, is now nearly 50 years old, and that during this period no material superior to Bordeaux has been found, there is now, more than ever before, an interest in and a search for better materials.

All the tests reported in this paper were conducted on the Experimental Farms of The Pennsylvania State College. The plots were in every sense field plots being actually portions of a large field, grown and handled in every way as a commercial field would be, including the use of standard high pressure field sprayers. It is obviously impossible to include in such tests all of the available materials. Our choice of

[1]Authorized for publication on November 27, 1943, as paper No. 1210, in the journal series of the Pennsylvania Agricultural Experiment Station, and as Contribution No. 141, from the Department of Botany.

materials to be tested has included some which are well known and which have been promising in tests elsewhere. We have also been interested in a search for new materials especially those made from non-strategic ingredients. Since a large proportion of these fall short in performance and will never reach the market or the attention of the grower, the data concerning most of them are reserved for publication elsewhere.

During the past three years we have tested about twenty different materials (many of them organic compounds) on russet rurals under Pennsylvania conditions. We are reporting here the comparative performance of certain materials which have shown promise in our tests.

Materials and Methods

The potatoes in all tests were Pennsylvania grown certified russet rurals. The sprays were applied with a power sprayer at approximately weekly intervals. In 1941 the plots were sprayed twelve times; in 1942 ten times, and in 1943 nine times. The rate of application in all instances was 125 gallons per acre per application.

1941 Experiment

This was a comparatively simple large scale test consisting of four treatments. Each treatment was made in duplicate on plots approximately an acre each in size. The yields of these plots are based on five one-hundredth acre samples from different parts of each one-acre plot. Yellow cuprocide and tribasic copper sulphate were used in amounts to give a copper content equivalent to that in the Bordeaux. Late blight, although present in the field, was not a problem. Both substitute coppers showed more tip burn than either of the Bordeaux plots, the vines also died and the tubers matured about a week earlier than the Bordeaux plots. The differences in yield, as shown in table 1, were not significant.

Table 1—*Average yield in bushels per acre*—1941.

Treatment	Yield
Bordeaux 8-8-100	415
Bordeaux 8-4-100	371
Yellow cuprocide[1]	372
Tribasic sulphate[2]	412

[1]Cuprous oxide. Rohm and Haas Company.
[2]$CuSO_4.3Cu(OH)_2$. Tennessee Corporation.

1942 Experiment

The plots in 1942 were eight rows wide and 100 feet long. Each treatment was replicated three times and the treatments were completely randomized within each replicate. There was considerable late blight in the field, enough so that all plots sprayed with materials containing less than two pounds of metallic copper (Table 2) showed significant reductions in yield. The addition of lethane derris to yellow cuprocide and of derris to tribasic sulphate still further reduced the yields; whereas the addition of nicotine sulphate to Bordeaux did not appreciably affect the yield.

Table 2—*Flea beetle and aphis populations, and yield for the treatments shown, based on means of three replicates, 1942.*

Treatment	Aphids per 10 Leaflets	Flea Beetle Punctures per 10 Leaflets	Bushels per Acre
1. Bordeaux 8-8-100			296
2. Bordeaux 4-4-100	38	133	239
3. Bordeaux 4-4-100 & 1 pt. Nicotine sulphate	8	171	246
4. Yellow cuprocide* 1½-100	44	109	247
5. Yellow cuprocide* 1½-100 & 2# Lethane Derris (20-80)	13	129	219
9. Tribasic Sulphate* 4-100 & ½# Soya flour			283
10. Tribasic sulphate* 2-100 & ¼# Soya flour	53	144	227
11. Tribasic sulphate* 2-100 & ¼# Soya flour & 4# Derris	2	71	204
12. Tribasic sulphate* 2-100 & ¼# Soya flour & 2# Derris	9	83	205

Least significant difference at 5 per cent 26 bu.
Least significant difference at 1 per cent 35 bu.
*See footnotes to table 1.

1943 Experiment

In 1943 the plots were reduced in size from eight rows to four, 100 feet in length. There were four replicates with the treatments randomized within each replicate. An attempt was made by adding talc to yellow cuprocide and to tribasic sulphate to obtain a spray deposit somewhat more like that produced by Bordeaux than is the case when these materials are used alone. It is of interest to note that the addition of talc significantly lowered the yield in the case of tribasic sulphate but increased the yield in the case of yellow cuprocide, as is shown in table 3. The results obtained with fermate and HE175 are of considerable interest. Both materials are organic chemicals, fermate having recently established its usefulness for certain purposes, (although not recommended for potato spraying) and HE175 being still in the experimental stage. In this test however HE175* was the only one of seven organic materials that resulted in yields on a par with Bordeaux and other copper fungicides.

Table 3—*Incidence of tip burn and yield for the treatments shown—based on means of four replicates*—1943.

Treatment	Ave. No. Tip Burned Leaflets per 50 Leaves	Yield Bu. per Acre
Bordeaux 8-8-100	58	226
Bordeaux 4-4-100	51	236
Yellow cuprocide 2-100	103	212
Yellow cuprocide & talc[4] 2-8-100	67	225
"Tribasic" sulphate 4-100	56	223
"Tribasic" & talc 4-8-100	87	193
Copper "A" compound[1] 4-100	74	218
Fermate[2] 2-100	81	183
HE 175[3] 2-100	99	221
Least significant difference at 5 per cent	45	26
Least significant difference at 1 per cent	..	35

*See footnote table 3.
[1]Copper oxychloride. E. I. du Pont de Nemours & Co.
[2]Ferric dimethyl dithiocarbamate. E. I. du Pont de Nemours & Co.
[3]Disodium ethylene bisdithiocarbamate. Rohm & Haas Co.
[4]W. H. Loomis Talc Corporation.

Discussion

For three years the use of yellow cuprocide and tribasic copper sulphate has resulted in yields not significantly lower than Bordeaux mixture of comparable copper content. The possibility of "stretching" available supplies of copper fungicide by reducing the amount of copper in the spray formula is intriguing,—especially during war years. This would be quite possible provided only that we could prophesy outbreaks of late blight. During severe epidemics of late blight however, reduced formulae have failed to give satisfactory control and their use has resulted in significantly poorer yields. (Table 2). The addition of contact insecticides, such as Derris or nicotine sulphate can be shown to have an effect on insect populations, especially aphids, but often has at the same time a depressing effect on yield and is believed to be poor economy.

That several other fixed copper compounds can be expected to equal the two mentioned above is indicated by the performance of copper "A" compound in table 3. The promise of new and useful organic fungicides for the future appears to be upheld by the performance of HE175 (Table 3). That the potato grower will be confronted by the necessity of choosing from among an ever increasing group of useful fungicides seems not to be denied, although at present it seems equally true that there is nothing better than Bordeaux mixture.

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EFFECT OF DIFFERENT AMOUNTS OF SPINDLE TUBER AND LEAF ROLL ON YIELDS OF IRISH POTATOES[1] [2]

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The literature relating to leaf roll and spindle tuber of the Irish potato (*Solanum tuberosum* L.) is replete with statements to the effect that yield is markedly reduced by these diseases. On the other hand, no extensive information is available as to the effect of different percentages of these diseases on subsequent yield. The presence of a small number of plants infected with leaf roll or spindle tuber in a potato field grown for certification presents a problem as to the subsequent reduction in yield in the commercial crop grown from such seed stock.

State officials in charge of potato seed certification have frequently received complaints from commercial growers about reduction in yield when only a very low percentage of diseased plants occurred in fields grown from certified seed. Therefore, at the request of the Certification Committee of the Potato Association of America, experiments were made to determine the effect of different amounts of leaf roll and spindle tuber on the yield of marketable tubers in a number of varieties of potatoes in several states.

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[1]Cooperative investigations by the Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration, U. S. Department of Agriculture, and the Agricultural Experiment Stations of Alabama, Florida, Louisiana, Maine, New Jersey, and Virginia.

[2]The following men and agencies furnished land and assisted with planting, growing, and harvesting of the experiments in Alabama and Louisiana:

Otto Brown, Gulf Coast Experiment Station, Fairhope, Ala.
H. L. Darling, Gulf Coast Experiment Station, Fairhope, Ala.
Ted Wright, Gulf Coast Experiment Station, Fairhope, Ala.
H. K. Riely, Louisiana Southwestern Institute, Lafayette, La.
Mark Koehnke, Alliance, Nebr., furnished some of the spindle-tuber-infected stocks used in Alabama and Louisiana.

Methods and Materials

These experiments were located in Alabama, Florida, Louisiana, Maine, Maryland, New Jersey, and Virginia for a period ranging from 3 to 4 years, thus providing a wide range of soil types and climatic conditions which would influence the growth of the crop.

With the exception of the spindle-tuber-infected tubers of Triumph, all of the diseased and disease-free seed potatoes were produced near Presque Isle, Maine. Enough seed for the experiments was shipped to the respective locations several weeks before planting.

Diagrams indicating the positions of each virus-infected seed piece in every plot accompanied the shipment of seed stocks. The location of the infected seed pieces was accompanied with the aid of a set of random numbers. For example, since all plots were 50 hills in length a 4 per cent level of diseases would have 2 diseased seed pieces randomly placed with 48 healthy ones.

At planting time one person placed the virus-infected seed pieces in the plot at the location indicated by the diagram. Another followed with non-infected seed pieces and placed one at each location not already occupied by infected ones. Thus there was no chance for transfer of the virus from diseased to disease-free seed pieces.

The experimental plot arrangement used in these tests consisted of 8x8 Latin squares or randomized complete blocks, depending on the amount of seed stocks and land available. The plots consisted of single rows and were 50 hills in length.

General Effects of Leaf Roll and Spindle Tuber on the Potato Tuber

Leaf roll is of considerable economic importance, as all commercial varieties are susceptible to this disease, which causes a marked reduction in the yield of affected plants. The tubers of diseased plants are not only reduced in number and size but also when used for seed, produce diseased progeny. Seed pieces of leaf roll-infected plants commonly remain hard throughout the growing season,—some may even fail to germinate and produce plants. Tubers of diseased plants are frequently attached so close to the stem as to appear attached directly to it.

Spindle Tuber

Losses due to spindle tuber are of a two-fold character—spindle tuber reduces the yield (Figure 1) and also impairs the market quality of the crop. Probably the most diagnostic symptom of spindle tuber is

FIGURE 1.—Effect of spindle tuber on yield at Hastings, Florida in 1939. Center hill is from spindle-tuber-infected plants; hills on either side from healthy plants.

the poorly shaped tubers which are usually small, elongated or spindle shaped (Figure 2), and which occasionally show numerous and prominent eyes. Frequently the tubers have a pronounced constriction near the middle, which gives them a "dumb-bell" shape. Oval tubers tend to become more elongated. In the Triumph variety diseased tubers are a

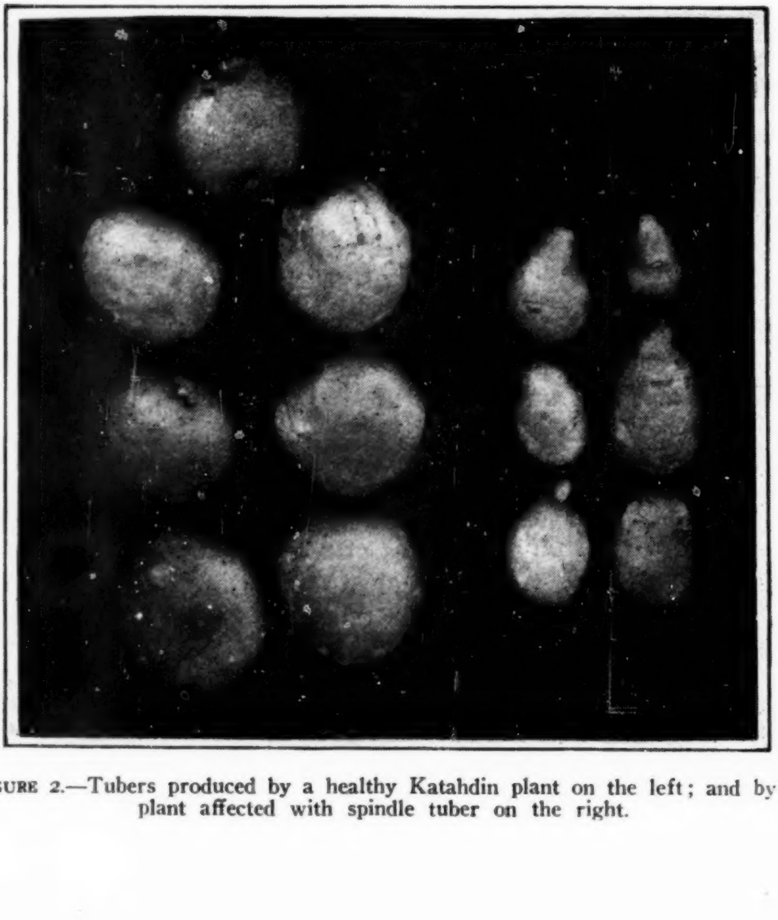

FIGURE 2.—Tubers produced by a healthy Katahdin plant on the left; and by a plant affected with spindle tuber on the right.

lighter red color than are the healthy tubers. Affected tubers usually sprout more slowly than do healthy ones.

It is not uncommon to observe that spindle tuber-infected plants are more severely injured by leafhoppers than are adjoining healthy plants. Thus spindle-tuber plants no doubt would yield better where the leafhopper population is low than where it is high.

Effect of Different Amounts of Spindle Tuber and Leaf Roll on Yield

The yields of marketable tubers (No. 1 grade) obtained at the 8 different levels of spindle tuber and of leaf roll in each experiment are presented in tables 1 and 2. It is apparent that the general trend is for a progressive decrease in yield as the amount of either disease increases.

In a study of this kind it becomes necessary to determine the point (percentage of disease) at which, in comparison with the healthy plants (0 per cent disease), a statistically significant reduction in yield occurs. From this standpoint the data in tables 1 and 2 present some pertinent relationships.

Under the conditions of these experiments, the reduction in yield with 4 per cent spindle tuber was not significantly different from that with 0 per cent in any of the experiments with the exception of Irish Cobbler in Virginia in 1940 (Table 1). With leaf roll, a similar situation existed, with the exception of the tests made in Louisiana with Katahdin in 1940 and 1941 (Table 2), in which two instances a significant reduction occurred with 4 per cent leaf roll. Even with 8 per cent spindle tuber or 8 per cent leaf-roll-infected plants, in only 3 experiments were the yields significantly below those of healthy plants, and these three instances were concerned with spindle tuber.

Thus, from the standpoint of the commercial potato grower who plants certified seed the chances are slight for a marked reduction in yield with 4 per cent spindle tuber or 4 per cent leaf roll. Likewise, the number of instances, in these experiments, in which significant reductions in yield occurred with 8 per cent spindle tuber or 8 per cent leaf roll were relatively low. The reduction in vigor of plants in the 100-per cent-infected plots with either spindle tuber or leaf roll is apparent in figure 3.

Although the reduction in yield obtained from 4-per cent leaf roll seed was not statistically significant in a majority of instances, yet it should be emphasized that under favorable conditions for current-season infection the market quality of the crop produced can be serious-

TABLE 1.—*Effect of different percentages of spindle tuber on yield of marketable tubers (No. 1 grade) of several varieties of Irish potatoes. Yields are given in bushels per acre.*

State	Variety	Yields with Various Percentages of Disease								Difference Required for Significance
		0 Per cent	4 Per cent	8 Per cent	12 Per cent	16 Per cent	24 Per cent	32 Per cent	100 Per cent	
		Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	1
1939										
Florida	Katahdin	293	280	302	289	303	282	290	278	1
Maine	Irish Cobbler	206	189	193	192	200	186	186	163	19
Maine	Green Mountain	218	223	215	219	230	206	204	204	15
Maine	Katahdin	223	222	219	211	216	206	200	197	18
1940										
Alabama	Triumph	133	131	138	124	131	121	119	57	13
Florida	Katahdin	309	310	298	300	307	291	300	256	22
Louisiana	Katahdin	130	127	127	122	120	109	106	58	9
Maine	Irish Cobbler	270	271	248	261	242	242	228	89	23
Maine	Green Mountain	398	405	370	353	349	321	306	88	28
Maine	Katahdin	266	261	263	263	253	235	233	117	20
Maryland	Chippewa	134	135	138	119	135	121	112	45	19
New Jersey	Irish Cobbler	282	286	266	271	263	248	234	89	15
Virginia	Irish Cobbler	304	278	285	259	256	248	230	94	18
1941										
Alabama	Triumph	182	175	175	176	167	162	150	85	13
Florida	Katahdin	118	119	119	112	105	112	100	78	16
Louisiana	Katahdin	186	185	173	169	159	181	160	102	23
Louisiana	Triumph	109	105	111	107	108	95	89	28	18
Maine	Chippewa	429	403	439	411	374	384	365	358	1
Maine	Green Mountain	506	536	484	531	494	529	445	390	64
Maine	Katahdin	455	429	436	418	439	405	394	280	33
Maine	Triumph	350	361	350	368	361	365	344	226	58

TABLE 1. *(Continued)—Effect of different percentages of spindle tuber on yield of marketable tubers (No. 1 grade) of several varieties of Irish potatoes. Yields are given in bushels per acre.*

State	Variety	Yields with Various Percentages of Disease								Difference Required for Significance
		0 Per cent	4 Per cent	8 Per cent	12 Per cent	16 Per cent	24 Per cent	32 Per cent	100 Per cent	
		Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	
1942										[1]
Florida	Katahdin	205	203	216	195	204	201	183	170	28
Louisiana	Katahdin	180	169	160	159	148	144	137	73	25
Louisiana	Triumph	88	78	75	74	67	63	52	34	14
Maine	Chippewa	468	446	453	401	415	420	358	272	70
Maine	Irish Cobbler	411	382	383	393	373	383	346	225	38
Maine	Green Mountain	446	455	440	413	415	397	404	255	40
Maine	Katahdin	354	325	326	291	305	319	290	164	38
Maine	Triumph	418	381	357	358	355	349	343	182	42
New Jersey	Irish Cobbler	258	245	248	231	233	235	196	89	27
Virginia	Irish Cobbler	87	84	77	76	73	86	74	34	17
AVERAGE		271	264	261	254	252	247	232	154	
AVERAGE PERCENTAGE REDUCTION			2.6	3.7	6.3	7.0	8.8	14.4	43.2	

[1]Value of F did not reach the 5-per cent point.

TABLE 2.—*Effect of different percentages of leaf roll on yield of marketable tubers (No. 1 grade) of several varieties of Irish potatoes. Yields are given in bushels per acre.*

State	Variety	Yields with Various Percentages of Disease								Difference Required for Significance
		0 Per cent	4 Per cent	8 Per cent	12 Per cent	16 Per cent	24 Per cent	32 Per cent	100 Per cent	
		Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	
1940										
Florida	Katahdin	358	355	347	341	329	314	311	138	25
Louisiana	do	118	100	113	95	95	85	90	31	15
Maine	Irish Cobbler	280	268	263	271	268	250	244	143	20
Maine	Katahdin	280	276	266	264	246	225	236	82	22
New Jersey	Irish Cobbler	281	276	270	275	260	258	252	172	16
Virginia	Irish Cobbler	265	259	257	261	250	235	226	135	18
1941										
Florida	Katahdin	103	91	94	78	89	96	74	35	26
Louisiana	Katahdin	199	178	170	166	156	147	150	104	21
Maine	Katahdin	465	437	407	411	420	382	388	206	56
New Jersey	Irish Cobbler	325	309	295	282	277	267	250	111	36
Virginia	Irish Cobbler	39	41	41	37	43	35	34	18	18
1942										
Florida	Katahdin	202	201	194	183	193	172	170	73	24
Louisiana	Katahdin	160	154	151	142	134	111	118	72	32
Maine	Irish Cobbler	381	410	380	353	364	362	321	157	43
Maine	Katahdin	398	354	392	357	344	334	315	92	47
Maine	Triumph	359	362	357	332	324	301	296	183	41
New Jersey	Irish Cobbler	234	244	256	227	231	221	216	153	28
Virginia	Irish Cobbler	88	82	87	74	84	68	69	49	12
AVERAGE		252	244	241	230	228	215	209	108	
AVERAGE PERCENTAGE REDUCTION			3.2	4.4	8.7	9.5	14.7	17.1	57.1	

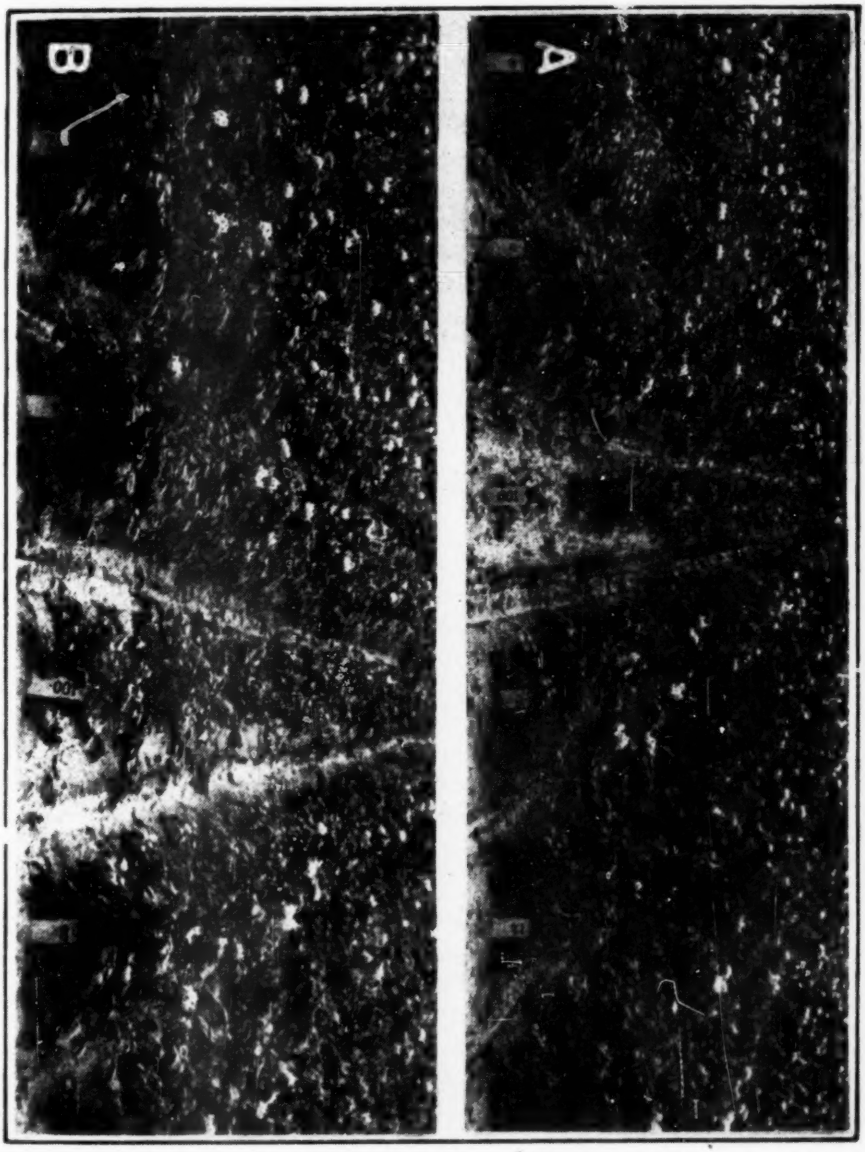

FIGURE 3.—Field views of spindle tuber (A) and of leaf roll (B) plots at Onley, Virginia, 1942. Numbers on stakes refer to percentages of disease in plots.

ly affected by net necrosis in both the Green Mountain and Irish Cobbler varieties.

The results of Tuthill and Decker[3] and Kirkpatrick and Blodgett[4] indicate that the reduction in yield from plots containing 10 per cent

leaf roll amounts to only slightly more than 3 per cent when compared with the yield from healthy plants.

In some of the present experiments the point of significant reduction in yield was found to be between 32 and 100 per cent diseased plants. Such was the case with spindle tuber in the Katahdin variety grown in Florida in 1940 and 1941. Similar relationships were found with leaf roll in Irish Cobbler in New Jersey in 1942.

The data in tables 1 and 2 indicate also that spindle tuber and leaf roll caused a greater depression of yield in some seasons than in others. For example, the point of significant reduction with spindle tuber in Katahdin grown in Maine was 32 per cent, in 1939; 24 per cent, in 1940; 12 per cent, in 1941; and 12 per cent, in 1942. Similar contrasts are to be found in the data dealing with leaf roll in table 2.

Relation of Varieties, Locations, and Seasons to Percentage Reduction in Yield

Due to the wide geographical area over which these tests were made and the different varieties involved, it is of interest to determine the effect of these factors on the percentage reduction in yield caused by spindle tuber and leaf roll. The percentage reduction herein discussed represents the percentage obtained by dividing the difference between the yield of marketable tubers produced by 100 per cent healthy and 100 per cent diseased plants by the yield from the 100 per cent healthy plants, and multiplying the quotient by 100. Comparisons were made to determine the effect of these two diseases on the yielding ability of different varieties and the effect of location on the percentage reduction in yield.

Three group comparisons of percentage reduction are possible from the data on spindle tuber in table 1. These are presented in table 3 and represent the effect of spindle tuber on (1) Green Mountain and Katahdin varieties in Maine in 1939-1942, inclusive; (2) Irish Cobbler, Green Mountain, and Katahdin in Maine in 1939, 1940, and 1942; and (3) Triumph and Katahdin in Louisiana and Maine in 1941 and 1942. Statistical analyses indicate that in comparisons where more than one variety was involved, no significant varietal difference was evident. Thus, different varieties in each comparison behaved similarly as regards the effect of spindle tuber on percentage reduction in yield. Also, the varieties behaved similarly over the period of years of the tests, as is shown by the fact that the interaction of varieties and years was non-significant in each comparison. It is of interest to note, however, that the percentage reduction in yield was significantly greater

with both Katahdin and Triumph in Louisiana than it was in Maine during 1941 and 1942.

TABLE 3.—*Percentage reduction in yield of marketable tubers of 4 varieties of potatoes due to 100 per cent spindle tuber in Louisiana and Maine.*

State	Variety and Average Percentage Reduction in Yield							
	Irish Cobbler		Green Mountain		Katahdin		Triumph	
	No. of Years	Per cent Reduction	No. of Years	Per cent Reduction	No. of Years	Per cent Reduction	No. of Years	Per cent Reduction
Louisiana					2	52.2	2	68.5
Maine					2	44.0	2	46.9
Maine			4	40.3	4	40.9		
Maine	3	46.2	3	48.5	3	43.3		

In table 4 is presented the average percentage reduction in yield caused by 100 per cent leaf roll with Irish Cobbler in Maine, New Jersey, and Virginia in 1940 and 1942, and also the effect on Katahdin in Florida, Louisiana, and Maine in 1940-1942, inclusive. That the location may also influence the percentage reduction in yield caused by leaf roll is apparent with Irish Cobbler where the reduction was significantly greater in Maine and Virginia in 1940 and 1942 than it was in New Jersey. Likewise, the disease was more serious with Katahdin in Florida and Maine than in Louisiana. Statistical analyses indicated that there were no significant differences between years or for the interaction of years and states with either Irish Cobbler or Katahdin. Thus there was no differential percentage reduction with regard to the 2 varieties in the several years and the locations (States).

Three comparisons (Table 5) involving both spindle tuber and leaf roll are possible from the data presented in tables 1 and 2. These comparisons include the percentage reduction in yield caused by these two diseases with (1) Irish Cobbler and Katahdin in Maine in 1940 and 1942; (2) Irish Cobbler in Maine, New Jersey, and Virginia in 1940 and 1942; and (3) Katahdin in Florida, Louisiana, and Maine in 1940 to 1942, inclusive. Leaf roll caused a greater reduction in yield with Katahdin in Maine in 1940 and 1942 than did spindle tuber, whereas the difference between the effect of these two diseases with

Irish Cobbler was not significant. On the other hand, spindle tuber was more serious with Irish Cobbler during these two years in New Jersey and Virginia (Table 5) than was leaf roll. With Katahdin in Florida, Louisiana, and Maine in 1940 to 1942, inclusive, the percentage reduction was markedly and significantly greater with leaf roll than with spindle tuber as an average of all the tests involved in the comparison.

TABLE 4.—*Percentage reduction in yield of marketable tubers of Irish Cobbler and Katahdin varieties of potatoes due to* 100 *per cent leaf roll in several states and years.*

State	Variety and Average Percentage Reduction in Yield			
	Irish Cobbler		Katahdin	
	No. of Years	Per cent Reduction	No. of Years	Per cent Reduction
Florida			3	62.9
Louisiana			3	56.6
Maine	2	54.6	3	66.8
New Jersey	2	36.9		
Virginia	2	47.9		

SUMMARY

Experiments were made to determine the effect of different amounts of spindle tuber and leaf roll on yield of marketable tubers in several varieties of Irish potatoes in seven states during the period of 1939-1942, inclusive.

The trend was generally for a progressive decrease in yield as the amount of either disease increased. The reduction in yield at 4 and 8 per cent spindle tuber or leaf roll is relatively small from the standpoint of the commercial potato grower.

In all comparisons involving more than one variety infected with 100 per cent spindle tuber, no significant varietal difference was evident. Katahdin, Irish Cobbler, and Green Mountain were similarly affected by spindle tuber. The percentage reduction in yield due to 100 per cent spindle tuber was significantly greater with both Katahdin and Triumph in Louisiana than it was in Maine during 1941 and 1942.

TABLE 5.—*Percentage reduction in yield of marketable tubers in Katahdin and Irish Cobbler due to 100 per cent spindle tuber or leaf roll in several states and years.*

State	Diseases, Varieties, and Percentage Reduction in Yield							
	Spindle Tuber				Leaf Roll			
	Katahdin		Irish Cobbler		Katahdin		Irish Cobbler	
	No. of Years	Per cent Reduction	No. of Years	Per cent Reduction	No. of Years	Per cent Reduction	No. of Years	Per cent Reduction
Florida	3	20.3			3	62.9		
Louisiana	3	53.0			3	56.6		
Maine	3	47.0			3	66.8		
Maine	2	54.7	2	53.9	2	74.3	2	54.6
New Jersey			2	67.0			2	36.9
Virginia			2	67.3			2	47.9

The reduction in yield due to 100 per cent leaf roll was greater with Irish Cobbler in Maine and Virginia in 1940 and 1942 than it was in New Jersey. This disease was more serious with Katahdin in Florida and Maine than in Louisiana.

Leaf roll was more serious on Katahdin in Maine than was spindle tuber, whereas the two diseases were equally detrimental to Irish Cobbler. On the other hand, spindle tuber was more serious on Irish Cobbler in New Jersey and Virginia than was leaf roll. The percentage reduction in yield caused by 100 per cent leaf roll was markedly and significantly greater than that resulting from 100 per cent spindle tuber in the case of Katahdin in Florida, Louisiana, and Maine during 1940 to 1942, inclusive.

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NAMING SELECTIONS FROM ESTABLISHED VARIETIES

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In an article in the September 1943 Potato Journal by Dr. William Stuart concerning the work of the Potato Nomenclature Committee, it is suggested that the variety Toanco No. 4 be called Toan's Rural New Yorker No. 2. Since the writer made the original selection of the potato which became Toanco No. 4, it might be well to set the record straight.

Nearly fifteen years ago Mr. Lewis A. Toan bought some Russet Rural seed potatoes from a grower in Michigan. Several hundred tubers, large enough to quarter were selected and planted in a tuber-unit seed plot. Among the progeny a number of tubers with some white skin on an otherwise russet potato were observed and saved for further testing. One of these tubers happened to be definitely marked as to white and russet skin; the line of demarcation between the two areas passing through an eye. The progeny of the white-skinned portion of this tuber produced the Toanco No. 4.

As the supply of seed stock from the smooth-skin section increased, it was tested against standard sorts. The high yielding ability of this line soon became apparent, and under growing conditions in Wyoming County and in several areas of Pennsylvania it proved to be superior to many other strains of Smooth Rural and the Russet Rural.

After it had been tested in many places for a period of years the white-skin strain was named Toanco No. 4, adapting the name from the words, Toanço Farms. If it helps to avoid confusion and to identify the origin, then the writer (and he thinks Mr. Toan would agree with him) would be glad to name the variety Toanco Rural. Inasmuch as this variety originated as a sport from the Russet Rural, the writer does object to the unnecessarily cumbersome name, Toan's Rural New Yorker No. 2 or Rural New Yorker No. 2, Toan's selection.

The Toanco Rural is very similar to the Russet Rural. It has the vigor of growth, productivity and quality of the Russet Rural. Except for the white skin it would be extremely difficult to distinguish between the two varieties.

Since another excellent variety of Rural potatoes was produced in much the same way, the story of its development is included in this

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article. The variety, Pioneer Rural was originated just prior to 1930. The selections were made by Mr. Fred S. Hollenbeck of Tully, New York, one of the better producers of foundation stock seed potatoes in New York.

The quotations which follow are from a letter recently received from Mr. Hollenbeck. "In 1914 we obtained four barrels of ——— Russet seed potatoes. This was good seed and I later heard it had been brought in from Michigan in carlots by ———. We grew this variety many years from the original seed practicing the mass hill selection method, digging a seed plot by hand and saving the highest yielding hills to plant the seed plot next season."

"We used to soak the seed in corrosive sublimate solution. When the tubers were wet we noticed quite a few during the season which were part white and part russet skin. Often the demarcation would be very clear around the whole tuber. As the demand for a high yielding white skinned variety increased, we decided to try developing one from these mutants."

"In 1926 and 1927 we made a large number of selections of mutant tubers which were planted individually. In 1928 we identified these with numbers. At one time we had over one hundred. We narrowed these down to 4 and the first Pioneer Rurals sold may have been any of these tuber lines or a mixture. However, after about two more years all sales were from one of these tuber lines, the X89, which seemed to be just a little more vigorous than the others."

The quotation which follows is taken from one of the advertisements which Mr. Hollenbeck put out a few years ago. "The Pioneer Rural is a new variety developed over a period of four years, from bud mutations of one of the best strains of Russet Rurals. It has all the good qualities of the Russet Rural—vigorous growth, disease resistance, high yield, a thick skin that will stand rough handling, shallow eyes and the best of cooking qualities. In fact it is the same as the Russet Rural in every way except that it has a white instead of a dark skin and produces a higher yield."

This variety could have been named Hollenbeck Rural but Mr. Hollenbeck preferred to use the name of his farm, Pioneer Farm, and so we have the variety, Pioneer Rural. The name Pioneer Rural is sufficiently descriptive of the source and the originator.

In the past the cereal seed industry has been fully as fruitful as the seed potato trade in the production of so-called variety names, such as Mortgage Lifter, Silver Dollar, and what not; yet so far as the writer knows there has been no attempt to include as part of the new varietal

name, the name of the old variety out of which a selection may have come. The plant breeder, for instance, who made head selections within Canada Cluster oats, finding one that later was proven to be better did not name it, "Canada Cluster, Cornell Agricultural Experiment Station selection"; he named it Cornellian. Some would say that it is no more a new variety than is the Number Nine or Heavyweight out of Smooth Rural, yet the farmers of New York State, appreciating its worth, grow and buy and sell Cornellian as a distinct variety with no thought regarding its origin.

How sure are we that the old variety was really a different variety? Just where should we draw the line between what is to be a new variety and that which is only a slight improvement on an established sort? Already what we used to talk about as Smooth Rural and Russet Rural, in accordance with Dr. Stuart's nomenclature, should now be spoken of as Smooth and Russet Rural New Yorker No. 2. After all, the important thing to the potato grower is not what the origin of the new sort might be but whether it is better than any variety now being grown.

It would be very helpful to have a central testing agency, as Dr. Stuart suggests, to pass on the merits of any new strain before it is named and propagated; but some crops are so materially affected by their environment, the potato more so than many others, that there would need to be at least a dozen and maybe many more of these testing agencies. A very striking example of this situation is the Katahdin variety. First tested in Northern New York for several years, the yield always was at least a third less than Green Mountains and under Adirondack conditions the tubers were not sufficiently better in appearance to warrant any consideration. Yet when Katahdin was tried in Western New York it very soon was found to be highly desirable because of its resistance to several diseases and the production of a high percentage of smooth number-one tubers under almost any growing conditions.

The seed certification agencies in the several states are very helpful in this connection. Many of them require that a variety shall be recommended by the crop breeding department of their own agricultural college before they will certify seed of that variety. Eventually these varieties filter down through the foundation stock grower, to the grower of certified seeds, to the table stock grower and finally to the over-the-fence trade between farmers. More and more the better farmers are demanding seed of recommended varieties. In othr words the seed buyer of today is not so easily influenced by a label or variety name; he insists on knowing the performance record of the variety, and, if possible, the grower of the seed.

EDUCATIONAL WORK NEEDED,—PROMOTING CERTIFIED SEED*

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Every potato grower should use certified seed potatoes or the equivalent. We who are especially concerned, know the value and advantage of using certified seed, but does Mr. Average Farmer and Mr. Victory Gardener realize it. The best summary of the value of certified seed potatoes was made 20 years ago when H. C. Moore sent out a questionnaire and summarized the results of 11,627 tests of yields of certified and non-certified seed in 27 States and 8 provinces of Canada. The certified seed outyielded the non-certified by 40 bushels an acre and the potatoes produced were of better market quality. Tucker in 1937 estimated yields from certified seed about double that obtained through non-certified in Canada and ventured the opinion that the situation in the United States was about the same. Up-to-date figures showing the advantages of certified seed potatoes would be very useful at the present time.

We need to put more emphasis than ever before on the use of certified seed potatoes. (1) It is one way of increasing yields of a most important wartime food crop. With scarcity of labor, machinery and materials it is necessary to get the highest returns possible from each acre. We should provide enough good seed potatoes to meet all requirements. (2) Ring rot has threatened the potato industry and the use of certified seed, free from ring rot, is the principal control measure. Many other diseases, some of which are new, can be controlled by the use of certified seed. (3) New varieties are being introduced more than formerly, and the identity of these, as well as the older varieties must be maintained. (4) The certified seed potato industry needs firm backing.

Educational, promotional, or advertising work is a job for all. A large share of it falls on the Extension Service. But the State seed certification agencies, the State departments of agriculture and the experiment station, are in a position to do much along these lines.

What should be the nature of this educational effort? From the

*Abstract of discussion at Seed Potato Conference, 25th annual meeting of the International Crop Improvement Association, Chicago, Ill., November 30 and December 1, 1943.

extension standpoint we should try to show the value of using certified seed potatoes in all possible ways. The result demonstration in which certified seed is compared with non-certified is still good, and still has a place in areas where farmers are not sold on certified seed.

Also the seed-source trials conducted in several States, whereby seed from several sources are brought together and compared in test plots, are very useful. Tours and meetings are held at these trial plots, in order that growers may note the differences. Meetings, publicity, news items, radio and other teaching agencies are used in trying to bring about greater appreciation and use of certified seed. The cooperative purchase of seed potatoes in carload lots is an excellent educational activity.

This educational work should include information on the nature of diseases and problems concerned. It should show the purpose and explain the mechanics of the inspection and certification work. This work should explain the tolerances for diseases that are permitted. That certified seed may sometimes carry some diseases should also be pointed out. The growers should be shown that planting certified seed is not a guarantee that there will not be any disease in the crop, because some diseases are carried in the soil, and some are blown in by the wind or brought in by insects from neighboring fields; in other words, the more the user of seed potatoes understands about the nature of the inspection problems, the more satisfied the customer will be.

In support of this grower education, State certification agencies will need to continue to work untiringly to maintain high quality, improve standards, lower tolerances for diseases, and otherwise help produce superior seed that will really justify increased prices, and the name "certified."

SECTIONAL NOTES

CALIFORNIA

Several cars of War Approved Seed which arrived in California recently were turned down by the local County Inspectors. It is apparent that there should be a little more cooperation among the various departments.

The Old Potato Market in California continues at, or close to, ceiling on best grades and firm on #2's.

In view of the report that Kern County will be an average of two weeks later than last year, old potatoes should clean up without any trouble in the West. (Mar. 11)—ERNEST MARX.

FLORIDA

The potato crop of 15,000 acres in the Hastings section, Florida is in good condition. Rainfall and temperatures, following planting in late December and January, have been almost ideal for the growth of potatoes. Late blight has not appeared and only a trace of mosaic and other diseases have been seen in fields visited.

It is too early to estimate the yield since at least four weeks must elapse before the crop will be made in the early-planted fields. During this time unfavorable weather and the occurrence of late blight may reduce yields considerably. Digging will probably get underway by the 15th of April.

The percentages of the acreage planted to the different varieties are as follows: Sebago 65 per cent; Katahdin, 28; Bliss, 5.5; Pontiac, 1.2 and Sequoia, 0.3 per cent. (March 10)—A. H. Eddins.

IDAHO

Up to and including March 1, Idaho shipments were approximately 31,000 cars. This should leave only six or seven thousand cars to clean up Idaho's biggest crop in history. Prices have been a little weaker and movement not so fast as earlier in the year. Shipments of No. 2's to dehydrators have somewhat relieved the situation on this grade. The potato acreage for 1944 will apparently be somewhat under 1943 with intentions to plant indicating between 160 and 170 thousand acres. Prospects of a short water season may further affect acreages of crops having a high water requirement.

The demand for certified seed has been good, and all the Idaho crop will move at ceiling prices. Inquiries indicate that there will be another increase in certified seed acreage for 1944. Several new areas may open up in production of seed as well as increases in the established areas. No War Approved seed was inspected for Idaho in 1943. A recent quarantine was placed in effect excluding all seed potatoes from Idaho except certified seed, and permitting entry of certified seed only from states which maintain a zero tolerance for ring rot.

From present indications, the potato acreage for 1944 will be more restricted to the established potato growing areas and to those farms which have potato equipment and storage. (Mar. 7)—Eugene W. Whiteman.

INDIANA

Naturally, there will be quite an interest among the victory gardeners in the state of Indiana for a good crop of potatoes in 1944. We

have a number of growers and also local merchants who have contracted for the potatoes and we are buying state certified seed and not the war approved seed and in all cases the orders have been greater than for the past two or three years. We do find some differences in the price, however, delivered to Indiana points, but the price seems to be within reason and I do not see why people will not be able to buy potatoes of some sort or other for this coming season. Our commercial growers are going to plant about the same acreage as in years past, but the great increase in potato production will come from the urban and city gardeners and the situation seems to be well in hand at this time. We are very much afraid of the war approved seed and, personally, I can see no need of putting it on the market. (Mar. 6)—W. B. WARD.

LOUISIANA

The Irish potato situation in Lousiana has been discouraging during the month of February. Rains continued until the last week of the month and planting was very limited. The amount of seed arriving in the state shows a 14 per cent increase in planting; however, I am confident that it will not be this high because of the delay in planting and also on account of some damage to the crop. By the latter part of February there was still 30 to 35 per cent of the crop yet to be planted. The principal question of interest to Louisiana growers now is, what will the support program be. (Mar. 4)—P. T. ECTON.

NEBRASKA

The situation existing in Nebraska market for potatoes has continued to deteriorate since the first of the year. The only bright spot in the picture is the fact that No. 1 washed table stock has sold at the absolute ceiling price throughout the period. The high percentage of low grade stock resulting from a rather unsatisfactory harvesting season, has caused most of the difficulty. All of the lower grades of stock have been sold with difficulty, if at all, and the Commodity Credit Corporation plans to purchase about 2,000 cars of U. S. No. 1 grade or better. These potatoes will be dehydrated for stock feed, or will go into commercial alcohol production. This should relieve the situation materially, and absorb most of the low grade potatoes that it was feared would be a total loss.

Certified potatoes have finally been cleaned up, the last shipments going forward at this time. Prices dropped somewhat from those received in mid-winter, when Nebraska Certified seed was selling at the ceiling.

The sales on War Approved seed were very light throughout the season. The only movement that was satisfactory was early in the year, when a fair quantity was shipped to Texas. Since the turn of the year, practically no War Approved sales were made, and these potatoes are being sold as table stock. Some of this poorer quality War Approved seed will be bought by the government for dehydration.

There is little to be reported on planting intentions at this time, though it appears that about the same acreage will be planted as last year. Because of the good prices received for certified, the acreage of certified seed may be increased.

Reports from central Nebraska, where potato planting will begin by the end of March, are that the Red Warba variety is rapidly pushing out other varieties. The only limiting factor is shortage of seed at this time. In previous years, Cobblers and Triumphs were the bulk of production in that territory. (Mar. 10).—MARX KOEHNKE.

NEW JERSEY

Many potato growers have been cutting seed for several weeks. They have most of their fertilizer in the barns and are practically ready to start planting as soon as weather conditions permit. Intermittent rains have prevented much spring plowing but it is hoped that this will get under way by next week.

Intentions to plant now indicate that the acreage will be about 71,000 acres, the same as was planted last year instead of the 72,000 to 73,000 as indicated on January 1.

The new ruling by Selective Service may greatly curtail the man power on many potato farms and force a further reduction in intentions to plant.

Prices for most varieties of seed potatoes are at the same level as last fall with most offerings ranging from $2.50 to $3.50 f.o.b. Maine. These relatively low prices are due to several factors. A larger percentage of seed was purchased last fall than usual and this has resulted in a decrease in the spring demand. The greatly increased supply of seed produced last year has also been a factor in the relatively low price. In addition to these reasons, the present poor table stock market and the lack of a policy on support prices has further reduced demands.

Some dealers are purchasing more seed from North Dakota and Minnesota than has been the case in previous years, because practically no potatoes are available from Prince Edward Island,—formerly the source of much of the certified seed used in New Jersey.

Approximately 50 per cent of the acreage will be of the Katahdin

variety, whereas Cobbler and Chippewa will form about 25 and 15 per cent of the acreage, respectively. The remainder of the acreage will be mostly Green Mountains, Sebagos, and Houmas.

Practically all of our seed is certified stock with little or no demand for War Approved seed.

Approximately 250 cars of old potatoes are in storage in New Jersey and market prices are about 50 cents a hundred below the support price, but there is practically no demand. The Commodity Credit Corporation is arranging to purchase 100 cars of potatoes a day,—five from New Jersey,—for the manufacture into commercial alcohol. Purchases will be made direct from the farmers at $2.15 per 100 pounds for U. S. No. 1's and $1.15 for U. S. No. 2's.—loaded in bulk in cars. This movement should ease the situation a little. (Mar. 17).—J. C. Campbell.

Pennsylvania

Certfied seed potatoes have not been moving so fast as growers had anticipated. Many orders were booked last fall, but orders this spring have been rather slow coming in, caused probably by the recent slump in the table stock market. Seed growers report many inquiries for seed, but few orders.

Seed potatoes stored better this year than for many previous years. There has been very little breakdown because of rot. Tubers are dormant and firm and are grading out into a high percentage of No. 1 stock.

Labor is scarce and although most growers have plans for a slight increase in acreage for 1944, very few expect to be in a position to carry out their plans because of the recent change in the status of many farm boys under the Selective Service requirements for deferment. Most growers that were recently contacted feel that they will be forced to reduce their potato acreage because of the acute labor situation. (Mar. 13).—K. W. Lauer.

Texas

The spring planted Triumphs in the Lower Rio Grande Valley escaped any serious cold injury, and made excellent progress during February.

A threatened shortage of irrigation water during the critical labor forming period in late March might reduce the yield to a marked degree.

An outbreak of late blight, which is very usual for this region, threatened the crop for a while; but the use of aeroplane dusting, coupled with good potato weather, seems to have checked the spread of this disease.

Insects are seldom a factor in this region, and seem to be even less prevalent this season than is usually the case.

Excellent yields of Sebago, Chippewa, Katahdin and Sequoia potatoes were produced during the fall season; but certified seed of these varieties were not available to Valley planters during the spring planting season. (Mar. 13).—W. H. Friend.

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THE INHERITANCE OF DRY-MATTER CONTENT IN POTATOES

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Knowledge of the inheritance of dry-matter content in potatoes concerns the potato breeder, producer, and consumer for several reasons. First, however, it is necessary to understand the relationship of dry-matter content to specific gravity, starch content, and to mealiness.

The potato is a combination of dry matter and water. The proportion of these two factors determines to a great extent its food value and culinary quality. A good mealy potato will consist of about 25 per cent dry matter and 75 per cent water, and as dry matter decreases in potatoes sogginess will increase.

The dry-matter content can be divided roughly into approximately 70 per cent starch, 20 per cent cellulose, and 10 per cent protein. Since most of the dry matter is starch, there is a high relationship between tuber density and starch content. This fact has been shown by previous investigators.

A high correlation between dry-matter content as measured by the specific gravity of the raw product and mealiness of the cooked product

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has been shown by Clark *et al.* (3). Mealiness is one of the more important characters affecting culinary quality. Flavor, flesh color, and freedom from blackening after cooking are some of the other factors.

Caldwell *et al.* (2) in their recent paper on dehydration of white potatoes indicate that potato samples with high specific gravity give larger yields of the dried product, are mealier or drier, and generally receive better over-all grades on quality than samples that are low in specific gravity.

It has been reported by Akeley and Stevenson (1) that potato varieties and seedlings are inherently different from one another in tuber density and that this can be determined best when they are grown under similar environmental conditions. Wide differences in the same variety were found when grown in different parts of the country.

There is now a demand from potato producers for new varieties with high dry-matter content, as well as resistance to virus and other diseases. Many individuals in the trade believe that only varieties high in mealiness should be grown for the table-stock trade. Also, the increase in demand for starch and dehydrated food from potatoes is evident. More efficient production can be attained for these by-products if the growers have access to adaptable varieties comparatively high in dry-matter content.

The potato breeder must know the dry-matter content of the parent material and its mode of inheritance. Knowing this he can then breed new varieties high in dry matter, starch content, and mealiness. This paper is a continuation of such study, a first report having been made in 1943 by Akeley and Stevenson (1).

Materials and Methods

The varieties used as parents were selected because they represented a wide range in tuber density from very high to very low. All the pollinations were made in the greenhouse at Beltsville, Maryland, during the winter of 1940-'41. The seed resulting from this work was planted in the fall of 1941 in the same greenhouse. A single tuber from each seedling of this planting was harvested in January 1942.

The single tubers, grouped by families, were planted in single hills at Chapman, Maine, in the spring of 1942. The following year these single hills were increased to 10-hill rows. In the fall of 1943 selections of 10 to 20 tubers were made from these 10-hill lots and taken to Beltsville, Maryland, for specific gravity determinations.

The tuber density of the seedlings and varieties was determined by

the flotation method reported by Clark *et al.* (3). Twelve salt solutions with predetermined densities varying from 1.060 to 1.115 at intervals of 0.005 were used.

Results

The five parent varieties with their tuber-density rating means for 3 years are given in table 1. Green Mountain rated the highest with a

TABLE 1.—*Ratings of certain potato varieties used as parents, with respect to their tuber densities, for 3 years at Presque Isle, Maine*

Variety	Density-class Means[1]			Variety Average
	1941	1942	1943	
Green Mountain	9.4	9.8	8.9	9.4
47156	..	..	8.4	8.4
Katahdin	7.6	7.2	6.0	6.9
Earlaine	5.5	..	4.3	4.9
Earlaine 2	3.6	3.9	3.0	3.5
Year average	6.5	7.0	6.1	

Density Class	Specific Gravity	Starch Equivalent
No.	Mean	Per cent
1	1.060	9.5
2	1.065	10.7
3	1.070	11.7
4	1.075	12.9
5	1.080	13.9
6	1.085	14.9
7	1.090	16.1
8	1.095	17.2
9	1.100	18.2
10	1.105	19.3

3-year average density-class mean of 9.4, indicating a specific gravity reading higher than 1.100 and a starch content of about 18.2 per cent. A high-quality seedling (47156) was second on the list with a specific density-class mean in 1943 of 8.4, indicating specific gravity of nearly 1.095 and a starch content of about 17.2 per cent. Katahdin was third, being intermediate between Green Mountain and Earlaine 2. The latter variety was the lowest of the group with an indicated specific gravity of about 1.070 and a starch content of about 12 per cent for a 3-year average. Earlaine was intermediate between Katahdin and Earlaine 2.

TABLE 2.—*Distribution of potato seedling varieties and parents for tuber density ratings. Grown at Chapman, Maine, in 1943*

Pedigree No.	Percentage and Parents	Distribution of Seedlings in Density Classes[1]										Total Seedlings	Means and Standard Errors
		1	2	3	4	5	6	7	8	9	10		
B 195	Green Mountain x 47156	..	..	..	2	6	19	30	30	26	7	120	7.55 ± 0.13
B 196	do x Earlaine 2	..	4	8	20	29	19	10	4	..	..	94	5.03 ± .15
B 197	do x Earlaine	1	3	9	12	23	24	13	6	3	..	94	5.39 ± .17
B 198	do x Katahdin	..	..	1	5	18	26	24	13	6	1	94	6.44 ± .14
B 199	Earlaine 2 x 47156	..	1	8	26	27	20	7	2	2	..	93	5.03 ± .14
B 200	Earlaine x 47156	..	2	3	15	28	25	12	3	..	..	88	5.35 ± .13
B 201	Katahdin x 47156	..	1	4	9	20	23	15	9	6	..	87	5.97 ± .17
B 202	Katahdin x Earlaine 2	3	19	27	23	15	6	..	..	..	..	93	3.49 ± .13
B 1048	Earlaine selfed	5	9	16	6	6	2	..	..	..	..	44	3.11 ± .20
B 1049	Earlaine 2 selfed	12	13	9	4	..	..	..	..	..	..	38	2.13 ± .16
B 1050	Katahdin selfed	1	3	27	16	20	10	4	..	..	..	81	4.20 ± .15
B 1051	47156 selfed	..	1	..	7	6	13	5	3	..	..	35	5.63 ± .23
Clone	Green Mountain (4 replications)	..	..	..	..	..	..	..	1	2	1	4	9.00 ± .41
Do	47156 do	..	..	..	..	..	..	..	2	2	..	4	8.50 ± .29
Do	Katahdin do	..	..	..	..	1	2	1	..	..	..	4	6.00 ± .41
Do	Earlaine do	..	..	1	1	2	..	..	..	..	..	4	4.25 ± .48
Do	Earlaine 2 do	..	..	3	1	..	..	..	..	..	..	4	3.25 ± .25

[1]See footnote under table 1.

The distribution of the progenies and parental lines for tuber density are shown in table 2. There are significant differences between seedlings within each family line, which indicate genetic segregation for dry-matter content.

Between the clonal varieties Green Mountain and 47156 there is no significant difference. This statement is also true for the comparison between Earlaine and Earlaine 2. Katahdin is significantly lower in tuber density than Green Mountain or 47156 but higher than Earlaine or Earlaine 2.

The differences between the means of the selfed lines are highly significant in all comparisons. These progeny means also have the same relative order for tuber density as their parents. The progeny of 47156 selfed is the highest, with Katahdin, Earlaine, and Earlaine 2 following with decreasing densities. In each of the selfed lines some seedlings were found that were as high in density as their parents, but if the means of the progenies are compared with those of the clonal lines, the parent varieties are significantly higher than their comparable selfed lines. This comparison suggests that the factors for high tuber density are dominant over those for low.

The cross B 195 (Green Mountain x 47156) shows what might be expected when two varieties high in specific gravity are used as parents. Approximately 28 per cent of the seedlings were as high as, or higher than, either parent.

The crosses B 196 (Green Mountain x Earlaine 2) and B 199 (47156 x Earlaine 2) show the segregations obtained when varieties high in specific gravity are crossed with a low one. These 2 family means are alike and are about 2 class-intervals lower than the mean of the Green Mountain x 47156 seedlings—a highly significant difference. After combining B 196 and B 199, approximately 34 per cent of the seedlings ranked in class 6 or above and were therefore as good as, or better than, the average of the means of their respective clonal parents. Only two of the seedlings of these crosses were as high in tuber density as either high parent, and 21 were as low as, or lower than, the low parent.

The cross B 198 (Green Mountain x Katahdin) represents a high x medium combination for tuber density, and it has a progeny mean of 6.44, which is approximately one class interval below the mean for Green Mountain x 47156, the high x high cross. About 7 per cent of the seedlings are equal to or better than the parent with high tuber density, and about 53 per cent are similar to, or below the parent, of medium density.

The progeny B 202 (Katahdin x Earlaine 2) shows the segregation

that occurs when two varieties, one medium and the other low in dry-matter content, are crossed. The progeny mean, 3.49, is a little higher than the mid-point between the means of the self lines of the two parents (B 1049 and B 1050) and about one and a half class intervals below the average, 5.03, for the high x low crosses (B 196 and B 199). Only 5 per cent of the seedlings in B 202 were as high as the Katahdin parent, and 53 per cent were as low as, or lower than, Earlaine 2.

There is no significant difference between the progeny means of B 197. (Green Mountain x Earlaine) and B 200 (Earlaine x 47156). This would indicate that Green Mountain and 47156 behaved alike in these crosses. A similar behavior was observed for Green Mountain and 47156 when they were crossed with Earlaine 2, since the progeny means of B 196 and B 199 are the same.

The cross B 201 (Katahdin x 47156) does not differ significantly from B 198 (Green Mountain x Katahdin), and its mean is also lower than the high x high density mean of the cross Green Mountain x 47156.

Discussion

The segregation in progenies from all the varieties used as parents shows that they are heterozygous for the character of dry-matter content. High tuber density seems to be dominant over low, as the four selfed lines indicated. Apparently several genes are necessary to explain the segregations obtained. The number of these genes cannot be ascertained from the present results, since it is difficult to determine definitely which part of the variabilty is environmental and which is genetic.

From the viewpoint of the plant breeder, however, the information obtained from the several clones, selfed lines, and crosses will be very helpful. By crossing two parents high in tuber density a relatively high percentage of the resulting seedlings will also be high in tuber density. If the tuber density rating of either one or of both parents is lower, then the chances of obtaining seedlings of high density are lessened accordingly. If both parents of a cross are as low as either Earlaine or Earlaine 2, it is doubtful if any of the resulting seedlings would be high enough in dry-matter content to be accepted.

Knowledge of the dry-matter content of the parents and, insofar as possible, of selfed lines is very desirable. Crosses can then be made in such a way as to increase the chances for selecting new commercial varieties with a higher dry-matter content than the ones now being grown.

SUMMARY

Since the breeding of new commercial varieties of potatoes high in dry-matter content is desirable, a continuation of the study of the inheritance of this character is important. The results for 1943 are reported in this paper.

Five parents were selected and used because of the wide differences in their specific gravity ratings. Tuber-density ratings were obtained for five clones, four selfed lines, and eight crossed lines. The eight crosses represented various combinations of dry-matter content as follows: High x high, high x medium, high x low, and medium x low. The cross with two high density parents gave the highest mean density for its progeny. This was followed in order by high x medium, high x low, and medium x low. Only a few seedlings in the latter combination would likely be high enough in dry-matter content for commercial purposes.

The five parent varieties are all heterozygous with respect to tuber density. High tuber density seemed to be dominant over low, since the progeny means of the four selfed lines were all lower than the respective means of their parents. The four selfed lines showed significant segregations. The number of genetic factors involved was not determined, but multiple factors seem necessary to explain the results.

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THE VALUE OF DDT FOR THE CONTROL OF POTATO INSECTS*

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Among 25 different experimental dust and spray combinations consisting of various commonly used insecticides and fungicides for the control of potato insects, several new materials were tried in factorial

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experiments during 1943 in Minnesota. Through the courtesy of Mc-Connon and Company of Winona, Minn., DDT was included in three experiments conducted under field conditions. These experiments comprised of carefully planned procedure with randomized plots in three replications in two of the fields where DDT was used at the levels of 1, 2½ and 5 per cent, with plots ranging from 0.383 to 0.424 acre each in comparison with other insecticides. The third experiment consisted of a single 2.12 acres plot treated with DDT at a 5 per cent level in comparison with the other five combinations of insecticides used on the same size plots in the same field. In all instances DDT was used as a dust in Pyrax ABB, and applied by field dusting machinery in the evening, usually in the presence of some dew. Field dusting operations with DDT were conducted between the 20th of July and the 27th of August, 1943.

A careful record of the ecological conditions was taken at the time of each application and in connection with the insect population studies (1) before each dusting, (2) usually within 24 hours after each treatment and (3) at other periodic intervals after dusting. The weather conditions, such as temperature, velocity and direction of wind, cloudiness, condition of plants, density of insect population, especially of the leafhoppers, fleabeetles and tarnished plant bugs, rate of application, drift if any and various other factors were carefully noted and utilized in subsequent observations. The insect population was determined by uniform sweeps with an insect net over the undisturbed plants at random in the two central rows of each plot.

These field experiments definitely indicated that DDT is safe to use on potatoes, for it is not toxic to potato foliage. It proved to be very efficient in the control of flea beetles in as low a concentration as 1 per cent. It is the most striking insecticide against flea beetles, much superior to any heretofore used. In all instances the analysis of variance for treatment in all applications of DDT gave highly significant results. The statistical analysis indicates that the treatment differences exceed .01 per cent point in favor of DDT for the entire period between the applications, thus strongly suggesting the residual value of DDT against flea beetles.

Although the data on the control of the potato leafhoppers are not so striking as for the flea beetles at the 1 to 2½ per cent levels, nevertheless at a 5 per cent concentration DDT is very effective against these insects for nearly two-week periods between the dusting operations, with highly significant results.

It proved to be very effective against the tarnished plant bugs

and other Mirids, especially the alfalfa plant bug, *Adelphocoris lineolatus* and *A. rapidus,* which are common in Minnesota potato fields. The toxicity of DDT to Mirids is apparently of a different pattern as compared with flea beetles. The mortality of the Mirids increased, while in the case of flea beetles it somewhat decreased in the period of six days after dusting under observations. It was also observed that it is toxic to Colorado potato beetles, especially the larvae in a low concentration of DDT.

These preliminary field experiments show that DDT is a very effective insecticide in the control of both mandibulate and haustellate insects in potato fields. In addition to the insecticidal value it has been observed that DDT apparently has a considerable fungicidal value as well, for the reason that the early and late blight of potatoes was not so prevalent in the plots dusted with a 5 per cent material as compared with the plots treated with some common fungicides ordinarily used in the potato fields.

The full usefulness of DDT as an insecticide or fungicide will be determined only after thorough studies of its selective effect on various insects and fungi, its toxicity and health hazards to higher animals. It has several decided advantages and economic considerations in the control of insects with diverse feeding habits. Its residual effectiveness is also of considerable value, yet its very residual insecticidal properties may have serious limitations in the use of it. Considering many positive and negative factors, it may prove to be of greater usefulness in the control of potato and similar insects than in the control of truck crop or fruit insects.

POTATO CULTURE AND STORAGE INVESTIGATIONS REPORTED DURING 1941 AND 1942[1]

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During the years 1941 and 1942, over a hundred articles dealing with culture, seed, varieties, fruiting, handling and storage have appeared in potato literature. Several of these are informative only and do not present data based on original investigation. Some of these are listed at the end of this paper and are referred to only briefly in the text. To

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avoid duplication, contributions appearing in the American Potato Journal are not cited. All papers dealing with the manuring and fertilization of potatoes have been reviewed in a separate number of the Journal and will therefore not be included in this article.

Culture

Orchard (65) has outlined the history of potato production in South Australia and described the factors affecting production there, giving cultural recommendations. Foulon (38) has presented basic information concerning potato production in the Argentine while Ratera (71) reports that the crop in Argentina often suffers from drought and that surface irrigation has proven beneficial. Jarvesoo (47) reports in detail on the cultural practices in Germany and gives a description of some of the tools employed. Storage in pits and as ensilage is also discussed. Trant (79) describes efforts and gives cost estimates to bring 3 areas of bracken lands in Montgomeryshire (England) into a stage of cultivation suitable for potatoes. Wellington (80) gives specific cultural recommendations for British growers who are contemplating expanding their wartime acreage.

Pereira (67) describes experiments conducted at Ottershaw College, Surrey, in 1937-'39 to determine whether inter-row tillage of potatoes was beneficial from the standpoint of weed control or if the soil mulch produced in weed control had any beneficial effects on the crop. Three main comparisons were involved: (1) weeds removed by scraping or hand pulling, the soil being only slightly disturbed; (2) weeds destroyed by repeated "grubbing," maintaining a fine tilth, and (3) a preliminary cultivation at an early date and then a second cultivation followed immediately by a hilling up of the plants. Results showed, that on light soils under conditions of three seasons, ridging was not beneficial when weeds were absent, that deep or frequent cultivations were not beneficial as expressed in terms of yield or per cent marketable size tubers. Weed competition was found to be most serious in the early stages of growth. It was concluded that cultivation should be designed primarily for weed control and to provide cover for the potato tubers. No moisture conservation was observed to result from a 3-inch soil mulch during dry weather even when the water table was at a depth of only 4 feet. There was a significant movement of water from the water table to the surface when the table was not more than four feet below the surface. The author suggests that soil type differences might make these results inapplicable to heavy soils.

In another publication Pereira (68) reports that placement of fertilizer in the "bouts" as compared with harrowing it in was beneficial and significantly reduced the percentage of marketable size tubers affected by sunburn on the scraped control plots.

Surdutovich (74) has succeeded in producing potato plants from sprouts with but little difficulty. Protection from the hot Russian sun was essential until roots had formed.

Bird (10) reports that climatic conditions on the Cumberland plateau of Tennessee are more suited to potato production than they are in the Knoxville region because of higher rainfall, lower temperatures and soils which respond well to fertilization. The early crop, grown from April to July, succeeds bests in this plateau region. Better results are obtained where cover crops (legumes) are used than where they are not. Crimson clover is recommended as a cover and green manure crop. The yields on newly cleared lands increased with the number of years under cultivation. Continuous culture markedly tended to increase the scab infection. Cobbler, Green Mountain and Triumph have been the leading varieties to date. Variety tests show that Chippewa, Pontiac, Sequoia and Sebago are well adapted to the region. Three years' spacing experiments showed that the best results were obtained when seed was planted 8 inches apart in the row. Fertilizer experiments indicate that 1,000 pounds of 4-10-4 per acre may be expected to give good results in the region, but where adequate disease and insect control is practiced more fertilizer is justified. Addition of minor elements has not improved the yield on new land.

Cordner (21), of Oklahoma, concludes that the most important factors in late crop Irish potato production were good stands, followed by the continuous development and maturation of the crop. High soil temperatures, especially 90-95° F. at planting time were decidedly destructive to potato seed pieces. The planting of freshly cut seed pieces was found desirable when the soil temperature was high because cut seed tended to develop a disorder resembling black-heart. Seed pieces affected with this disorder germinated slowly, and there was a direct relationship between rate of sprouting and survival of seed pieces. Refrigerated storage (50°) for spring-crop seed tubers was less desirable than cellar storage (70-80°) because the lower temperature stored tubers sprouted more slowly after planting. Ethylene chlorhydrin treatment hastened sprouting of spring-grown seed and favored a good stand, especially when whole tubers were planted throughout the usual planting season, but with cut sets only when the plantings were made early. Irrigation by overhead spray was the most effective method of reducing soil tem-

peratures to more favorable levels following planting, which was best done in rain-cooled soils. Best results were obtained when moderate to low ridge culture was used as compared with high ridges.

Eddins (34) states that during a 9-year period (1932-1940) the best yield of potatoes grown at Hastings, Florida, was obtained during a season when the rainfall was slightly less than normal and the lowest yield when the rainfall was very deficient. Diseases were of little importance during dry seasons and caused the greatest losses in exceptionally wet seasons.

Experiments in erosion control by Lyford (64) in New Hampshire potato fields showed that run-off and erosion prior to freezing is negligible and that run-off increases after freezing occurs but that soil loss is not severe. Soil loss in the winter is related to the depth of frost, duration of frost and the manner in which the soil thaws. The most critical time of the year for soil loss is in the spring when the soil is thawing from the top down and is essentially in a state of supersaturation. It is difficult to establish rye after the 1st of October by which time most potatoes are not yet dug.

Bushnell (16) has discovered that rye, sown in August, has been the best winter cover crop to precede potatoes on Wooster silt loam, which does not form a crumb structure. Its special value seemed due to the mass of fine roots produced during the fall, which retains the porosity induced by wetting and freezing of the soil in winter, and spring rains do not recompact the soil under rye. Winter barley or mammoth clover might prove as good as, or better than, rye.

Bushnell (18) has found that Chenango sandy loam is well suited for the production of early potatoes in Southern Ohio. Source of seed stocks did not seem to be an important factor. Rather heavy fertilization was essential for high yields, and succession cropping for 8 years had no detrimental effects on yield. August-sown winter barley was an effective cover crop.

Bushnell (17) concluded from experiments based on observations that on some soils potato roots extend below plow depth whereas on others they go only to plow depth and that suitable carriers of either nitrogen or phosphorus increased the quantity of roots in the subsoil. However, phosphorus or calcium added to the subsoil did not consistently increase the yield of potatoes even though there was an increase of roots in the phosphated subsoil.

Kraus (50) in a progress report from Idaho found that large seed pieces and close planting produce the best yields. Cut seed exposed to

hot, dry conditions decays quickly. Lack of moisture is a possible cause of jelly-end rot.

Dietz and Verner (29) describe an ingenious instrument for continuous recording of potato tuber growth by measurement of one diameter and present the growth record for a single tuber obtained over a period of approximately five weeks. This growth record indicates a diurnal periodicity in increase of diameter, there being an average daily period of 9 hours during the morning and afternoon when no growth occurred. This periodicity of growth is attributed largely to changes in atmospheric humidity, the periods without growth coinciding with periods of low atmospheric humidity. There was a steady decline of the growth rate as the season advanced.

The Nebraska Experiment Station (61) reports that Triumph potatoes crack badly at harvest time and cracking increases when transpiration decreases rapidly or is kept at a very low level. The cracking occurs during cool mornings on foggy, rainy days. When vines are practically mature, cracking increases as a result of direct absorption of moisture by the tubers from a very moist soil. Killing the vines with sprays reduced cracking but was not so effective as root pruning. Pontiac cracked worse than Triumph while a seedling, B5, cracked less. Warba and Mesaba cracked to some extent and Chippewa, Katahdin and Cobbler cracked scarcely at all.

Drew and Deasy (30) outline and discuss investigations of the relationship between various factors and the percentage of starch in potatoes. It appears that when potatoes are grown under normal conditions the higher the proportion of small potatoes, the higher the percentage of starch. Attention is called to the variation in the percentage of starch that occurs between samples within a variety. Hollowheart does not appear to influence the actual percentage of starch in tubers so affected, but would influence considerably the results by the specific gravity method unless such cavities had been exposed previous to the determination. The percentage of starch in storage falls up to December or January after which it again increases until May.

Seed

Grikhutik (41) conducted a series of experiments with a view to ascertaining the effect of vernalization on the yield of late-maturing varieties of potatoes used for industrial purposes. The replicated experiments began in 1934 at a White Russian Station. Vernalization was carried out by sprouting seed potatoes for 34-35 days at a temperature of 12-18° C in a well-lighted place, the seed pieces being carefully

spaced. The vernalized potatoes sprouted 6-8 days earlier than the unvernalized, which required 25-29 days. Budding, flowering, tuber formation, "drying-off" of the "haulms" were all noticeably earlier in the treated lots. Observations on development at 10-day intervals showed that in each instance the yield from the vernalized seed was the largest. Vernalization also increased the starch content. Compared with early and mid-season varieties, late varieties yielded the largest increment at the final digging. It was found that the effect of vernalization increased with increase in soil moisture and quantity of fertilizer. The yields from vernalized half tubers were equal to, or greater than, those from unvernalized whole tubers.

Ter-Saakian (76) describes a method for breaking the dormancy of newly harvested potatoes which was found to be effective in Armenian Russia. The soil in a trench is moistened, filled with newly harvested potatoes from the early crop, and covered with a layer of moistened straw. The July temperature in the trench was 25-30° C. The tubers sprouted in 12-15 days, and when planted in moist soil, produced a second high-yielding crop during the same season. Kravchenko (51) urges that early potato seed be dried and sprouted prior to planting. Drying was carried out at 12-15° C for 1 to 2 weeks until about 5 per cent loss of moisture had occurred. The tubers were then sprouted in slatted boxes or on peat or sawdust for 30-40 days resulting in a further 10 per cent loss of moisture. During sprouting they were kept at 15-18° C and kept moist. Bulkagova (15) found that according to the literature and results of his own experiments, sprouting of old potato tubers is closely connected with their water content. Whereas in young tubers a loss of 20 per cent of the initial content was required for sprouting, in old tubers a loss of from 3 to 4 per cent proved sufficient. Old tubers which had lost 5 to 6 per cent of their initial water content sprouted only after they had been placed in moist sand.

Chernov (20) found that the highest yields in Russia are obtained when large tubers are used for seed, or best of all, when seed tubers are selected from tubers of the highest yielding plants and from summer plantings.

Michener (54), from his experiments in Hawaii, reports on the shortening of dormancy of Bliss Triumph tubers through the use of ethylene chlorhydrin and other reagents. Experiments were conducted with dormant and semi-dormant seed from Hawaii and the Red River Valley of North Dakota. Tubers were exposed to vapors of ethylene chlorhydrin for periods ranging from 0 to 4 days,—some being given a second treatment. Treatment with 0.8 to 1.0 cc. ethylene chlorhydrin

per kilogram of potatoes for 3 days hastened germination without causing injury to dormant potatoes. Growth was stimulated even when treatments were applied at the time that the tuber had begun to germinate. This is true both for the tubers which are passing naturally out of their dormant period and for those in which growth has been started by a previous chlorhydrin treatment. To avoid injury to tubers that are beginning to sprout, it is recommended that they should be treated only for 1 to 1½ days and only when the buds are less than 1 mm. long. Ethylene chlorhydrin also increased the number of stems per seed tuber. The increase in average yield per plant was roughly proportional to the increase in the number of stems. From this it is inferred that the increased yield from the treated seed is a result of the increased number of stems per hill. Michener (55) states that further studies have shown that ethylene chlorhydrin increased the destruction of all or a large part of the auxin in the tuber. Subsequent to treatment the auxin content again rises in the course of a few days. Normally, as the buds of the tuber increase in size and elongate into stems, their auxin content increases. As a result, each larger bud inhibits growth in the smaller buds. Thus, only one or a few of the larger buds are able to grow. Therefore, the removal of auxin by the action of ethylene chlorhydrin removed the means by which one bud inhibits others, and permits a number of buds to begin development immediately after treatment. Michener (56) also reports experiments on dormancy and apical dominance in the Bliss Triumph, White Rose and Russet varieties of potatoes. The relationship of ethylene chlorhydrin treatments to the auxin in the buds was under special investigation. It was shown that apical and lateral seed pieces germinate at approximately the same time if they are cut out of the tuber in such a way that apical and lateral buds each bear the same special relationship to the cut surfaces around them. It was concluded that the apical buds inhibit growth of the lateral buds. This inhibition was shown to be caused by auxin produced in the apical buds. It was also shown that treatment with ethylene chlorhydrin causes a destruction of a large proportion of the auxin in the tuber. As the dominance of the apical buds depends on auxin which they produce, it was lost when the auxin was destroyed. The lateral buds were then able to grow.

Townsend (77) conducted experiments in which numerous stocks of Bliss Triumph potatoes of diverse origins, and often differing in maturity and storage periods, were variously treated with ethylene chlorhydrin (40 per cent solution), as whole or cut tubers, principally during the period 1934-'40 at the Florida Everglades Substation. A

number of seed stocks also received supplemental treatments with standard fungicides. Practical suggestions for the use of the treatment are included, together with a comprehensive review of literature on potato seed stocks covering 43 titles. The treatment has been valuable for the fall crop, for by hastening sprouting many seed pieces were saved from decay and the crop usually matured early enough to escape frosts. When fall-crop potatoes were used as seed for the spring crop, the treatment was needed to start growth early enough to produce a crop before hot weather prevented tuber setting. Increases in stand and yield have varied with stocks and season, but in general have been of importance. The greater productiveness of seed stocks harvested when somewhat immature was demonstrated.

Andersen and Fifield (37) in Florida also report success in the use of tetrachloro-ethylene for breaking the dormancy of Dakota-grown seed of Triumph potatoes.

As a result of investigations it is recommended by the Nebraska Experiment Station (62) that seed potatoes for mid-winter planting in the South be stored at 50° F. or that mid-winter shipments from cooler storage be warmed up for several weeks before shipping. A period of storage at 40° immediately after harvest followed by warm storage (60 to 65° F.) resulted in earlier or more rapid emergence of more vigorous sprouts than when tubers were stored continuously at 60 to 65° F. A further report (63) inquiring into the causes for the above phenomena shows that reducing sugars are relatively constant at 50°, while a rapid loss occurs at 75° and a rapid increase at 40° F. When brought back to 50°, the reducing sugars never go as low as when 40° conditions were not used. The rapid sprouting of lots that were cooled early and warmed later was caused by the large amount of readily available carbohydrates (as reducing sugars) found in the potatoes just as they were completing the rest period.

The Georgia Experiment Station (40) obtained data that showed higher yields from whole seed than from cut seed with both No. 1 and No. 2 size North Dakota grown seedstocks. Spacing tests with two sizes of seed piece showed that the highest yields were obtained at 8-inch spacing with .75 ounce seed pieces and at 6-inch with 1.50 ounce seed pieces where Triumph potatoes were planted in 3-foot rows and given 1,500 pounds per acre of 4-8-6 fertilizer.

Durham, Shaw and Christopher (32) concluded from their experiments that when 3 varieties of potatoes were treated with two kinds of wax and stored in a cellar at 42° F., considerable differences in yield were obtained among varieties and also w[illegible]h waxes and monthly treat-

ment dates. There was a greater tendency for mid-winter application to depress yield. Tubers treated with either wax contained about twice as many starch plastids as the check tubers, and the starch grains were large and evenly distributed throughout the cell. On the basis of limited data, waxing of seed as a means of increasing yields of potatoes was not advised.

Costantin and Miege (22) conducted experiments in which they discovered that more than one crop of potatoes could be successfully grown without importation of new seed to Morocco when the seed tubers were stored in cellars during the summer in the Atlas mountains, but not when they were similarly stored at Rabat in the coastal plains. This was true for all three varieties under test. An anonymous writer in Rev. Hort. suisse (19) gives several methods of propagating potatoes when seed stock is scarce, such as greensprouting, using eyes and even starting plants in the greenhouse.

Arnold (1) reports, from Rhodesia, that in order to cope with the hot, dry conditions in which seed potatoes must be planted there, cut seed pieces should weigh at least 3 to 4 ounces, and have one or two short, sturdy sprouts. Cut seed should also be well cured, and it is best to split the seed tubers longitudinally only. The reason for the speedy deterioration of imported potato stocks is ascribed to the necessity for keeping the seed tubers in high temperatures for some months after they have reached the optimum time of planting. Cropping power of imported strains could be better maintained if the seed could be kept in cold storage at 40° F. until climatic conditions become cooler and more favorable for growth.

Bell, Gibson and Dillon-Weston (8,9) of Cambridge, England, reported results of an experiment designed to compare the seed value of small whole tubers of "seed" size with cut seed from large tubers of marketable size. Previous experience and practice in the south of England has indicated poor results from cut seed due to rotting of the seed pieces. The principal varieties, Arran Banner, King Edward and Majestic, were used. No significant reduction in stand of plants resulted from cutting. Comparisons of yield were made as affected by cutting and length of time elapsing between cutting and planting, the cut seed being stored for periods of 1, 3 and 6 days under conditions favorable for curing. Although the cut seed did not yield quite so high as the uncut, the length of time elapsing between cutting and planting was not significantly effective.

According to results reported by Ellis (35) there is a difference between potato varieties in their reaction to apical dominance of the

seed pieces. In comparing the growth and yield from apical and stem end seed pieces from 3 varieties on muck soils in Indiana, it was found in all cases that plants from the pieces cut from the basal ends were slower in emerging than were plants from the apical pieces. The Russet Rural was generally slower than either Irish Cobbler or Chippewa in emerging. In the yield comparisons, apical pieces yielded barely significantly higher than stem end pieces with Cobbler and highly significantly better with Russet Rural and Chippewa. It is suggested, that in order to overcome this difficulty as well as that experienced with weak sprouting of stem-end seed pieces of such varieties as Chippewa, that relatively small seed tubers be used, and that these be cut only once,—on the longitudinal axis.

Barnes (5) in his work, claims that potatoes planted the first two weeks of February in the South Carolina coastal vegetable sections may be expected to produce more than those planted the last half of the month. Better results were obtained from shallow planted seed than from deep planted seed, but the difference was not statistically significant. The normally low rainfall that occurred during a 40-day period beginning the 10th of April and continuing to the 20th of May, in conjunction with high temperatures, is probably the chief factor responsible for this marked response to time of planting.

Dunn (31) from his investigation in New Hampshire gives the results of trials on the effect of soil moisture and fertilizer placement on the vitality of the potato seed piece. Whole and cut sets were planted in buckets at 18 to 20° C., and 14 to 15° C. in both clay and sandy loam. Fertilizer treatment included; none, 28 gm. (1,000 pounds per acre) of 8-16-16 in a circular band 2 inches wide, close to the seed; and 3 treatments 0.5 inches away from the seed including 28, 21, and 14 gms. The soil moisture levels involved were 50, 60, and 70 per cent of saturation. Injurious effects of the fertilizer were not evident in rates of emergence or of growth after emergence. All fertilized plants usually grew more vigorously and larger than the correspondingly unfertilized plants. Growth was greater in the lower temperature and in clay. Although an inhibitory effect of close placement of fertilizer was noted in early growth, it was not carried into later growth and tuber yield and its value as a criterion of fertilizer injury was doubtful. Tuber yield was usually greater with all fertilizer treatments than with corresponding unfertilized plants; with clay soil than with sandy loam; and greater at the cooler than at the warmer-growing temperatures. Soil moisture effects were evident in a greater yield with higher levels and in cool than in warm temperatures. Plants grown from cut seed in actual con-

tact with fertilizer showed distinct injury which is in agreement with results reported elsewhere.

Varieties

Balls (3) reported the findings and experiences of an expedition of the Imperial Agricultural Bureau of London, England, to the western slopes of the Andes to collect material for use in improvement of potato varieties. Collections of both native, cultivated, and wild species of Solanum were made between the altitudes of 4,000 and 14,000 feet in Argentina, Bolivia, Peru, Ecuador and Columbia. Among the species represented in the collection were *S. acaule, S. demissum, S. andegenum* and *S. yusupchukii* in their myriad forms. It was found that many of the native species would form tubers only under short days. Specimens of a species which may represent the link between the tuberous and the non-tuberous species were obtained. An oddity was a black-fleshed potato whose pigment is used as a dye by the natives.

Bukasov (14) has discussed the geography of the endemic potatoes of South America, considering them as Atlantic Coast, Pacific Coast and Andean groups. The groups of the cultivated species are also considered. In another paper (13) are listed several new wild species as follows: *S. henryi, S. sorianum, S. mercedense, S. mechonguense, S. millanii, S. laplaticum, S. boergeri,* and *S. horovitzii.*

Avanzi (2) has published a preliminary classification of the Italian varieties of potatoes. Snell (73) has published a note on three potato varieties, Erika, Fruhnudel and Robusta, claimed to be resistant to *Phytophthora infestans.*

The Maine Experiment Station has published data (52) from tests made in 1941 with 8 varieties grown at 3 spacings, 3 rates of fertilization and in two locations. Some varieties gave a better performance when planted relatively close (6 inches) although the trend in yield at the various spacings was in opposite directions at the two locations. When the yields for the two locations were averaged there was apparently little effect of spacing on yield. The yield ranking of the varieties in descending order was: Earlaine 2, Katahdin, Sebago, Chippewa, Warba, Houma, Green Mountain and Irish Cobbler.

Eddins (37) presented data showing that during a 3-year period (1938-1940) Sequoia, Sebago and Pontiac proved superior in yield to Katahdin and other new and standard varieties under test in Florida. Eddins and McCubbin (37) found, in 1941, that Sequoia, Sebago and Pontiac greatly outyielded Katahdin in 10 x 10 Latin Square trials at two Florida locations.

Two years' investigations by Telford (75) have shown varietal differences in susceptibility to wireworm (*Ludius aeriepennis destructor* Brown) attacks. Warba, Red Warba, Sebago and Bliss Triumph were less heavily attacked than Pontiac, Cobbler, Mesaba and Early Ohio. Wireworm injury was greater in potato varieties which have fewer tubers per hill and which have their tubers growing in close proximity to one another. Erwin (46) reports that Sequoia is much more resistant to hopperburn in Iowa than are Cobbler and Early Ohio.

Muller and Orth (60) conducted investigations designed to find a variety which might be used in conjunction with a winter catch crop on light soils. It was necessary to find one that was quick growing, that would produce tubers under short-day conditions, that was resistant to Phytophthora and that would stand two months' storage without sprouting. The variety BRA5/31 was found to approximate these conditions. Its growing period was 6 weeks less than most varieties. It was resistant to the Phytophthora biotypes of group A. It was found to contain considerably more arginin than the other four varieties tested. Its yield, though low, was adequate to justify commercial production.

Findlen (36) in his work, states that in certain cities of upstate New York, the newer varieties of potatoes such as Katahdin, Chippewa, Sebago and Houma are rapidly displacing the older Rurals, Green Mountains and Cobblers as favorites with the consumer. Farmers and the other packers prefer to pack these new varieties in consumer packages. The demand for the newer varieties increases with increasing income, and a definite premium was paid for them over the older varieties. A higher proportion of the newer varieties passing through the markets was of U. S. No. 1 grade than of the older varieties.

Reimann *et al* (72) report trials made to determine which varieties of potatoes show the greatest tendency to darken after cooking. Results were as follows: (where 0 means no blackening and 100 means dark gray) Triumph, 20; Chippewa, 21; Houma, 27; Katahdin, 29; Red Warba, 30; Cobbler, 37; Green Mountain, 38; Rural, 45; and Russet Rural, 49. These figures are the averages of five years' results. Additional tests have shown that both Sebago and Pontiac may be added to the list of varieties that tend to remain white following cooking.

In tests conducted at the Nebraska Station (63) pertaining to studies of heat and drought resistance, Cobbler and Mesaba withstood higher temperatures than did Katahdin and Warba. Triumph was the most susceptible to high temperatures. Potato plants were killed by heat more quickly in a humid than in a dry atmosphere. A total of

more than 300 strains has been tested at 118 to 119° F. for 6 hours. The varieties with the highest transpiration rates were the most heat resistant.

Flowering and Fruiting

Miller and McGoldrick (59) record the results of studies concerning the effect of length of day on vegetative growth, maturity, yield, and smoothness of tubers of Irish potatoes when grown under field and controlled conditions. With field and controlled experiments, plantings under short days showed less vegetative growth, matured earlier, and the potatoes were generally smoother. The opposite effects were obtained under long day conditions,—the plants were very vegetative, matured later, the tubers had deeper eyes and were more irregular in shape, although the total yields were generally higher. Seedlings representing several family lines were studied and the resulting segregations could be classified as either long or short-day plants. The parental combinations had a marked influence on whether the resulting seedlings would fall into the long or short-day group.

Werner (81) carried out studies to determine whether potato varieties can be analyzed as to adaptation to various latitudes by testing them under controlled conditions with the photoperiods and at temperatures characteristic of certain latitudes. The progressively changing day lengths and temperatures typical of potato growing seasons in southern and northern United States were simulated in the greenhouse. Plants of two vegetatively differing clonal lines of Triumph growing under these conditions with 11 and 16-hour days and with different levels of nitrogen nutrition were harvested at frequent intervals. With 11-hour cool days (62 to 65° F.) plants were very small with high leaf to stem and tuber to top ratios; and tubers set very early on a few short stolons, increasing rapidly in size early in the season, completing growth before the 75th day after emergence and having a high content of dry matter. The 16-hour cool day plants in comparison were much larger, had lower leaf to stem and tuber to top ratios; set more tubers several weeks later on larger stolons, and growth continued longer and finally attained about twice as much weight. Plants under "southern" conditions resembled 11-hour cool day plants except for slightly later and slightly less extensive tuberization. "Northern" condition plants were much like 16-hour cool day plants. Restricting the nitrogen in the nutrient solution for northern condition plants resulted in earlier cessation of vegetative growth, reduction in leaf to stem ratio, much earlier tuberization, reduction in number of tubers, greater

tuber weight and higher tuber to top ratios early, but eventually less, lower dry matter content in all parts and possibly lower starch content. Changes due to the restriction of nitrogen were similar, although less pronounced under southern conditions. The initial growth of the very early strain generally exceeded that of the very late strain. Where conditions favored vegetative growth early or throughout the season, that of the late strain was greatest, but the strains differed little in this respect when early conditions did not favor such growth. External shortage of nitrogen always inhibited growth of the early strain most. Early strain plants compared with late strain plants were mostly leafy, had highest leaf to stem ratios, least extensive stolen growth, formed tubers earlier, and had higher tuber to top ratios and greater tuber production per day per gram of leaf weight. Under northern conditions or with 16-hour cool days, late strain plants came into tuberization much later than the early strain, but differences were much less under southern or 11-hour day conditions with restricted nitrogen. Early strain plants produced the greatest total weight of tubers except when conditions late in the season greatly favored tuberization. Differences in dry matter and starch content of tubers were attributable to size and physiological age of tuber and not to strain differences. The late strain could survive adverse conditions and respond to improved nutrition conditions better than the early strain. The method of periodical harvesting of plants grown under controlled environmental conditions seemed much more satisfactory for determining significant physiological differences between clonal strains than field trials in different parts of the country.

In his studies, Bartholdi (6) reports experiments on the influence of flowering and fruiting on vegetative growth and tuber yield. The varieties chosen for all experiments represented different degrees of vegetative vigor, production of flowers and fruits, and tuber yield. To obtain this range two numbered selections of Russet Rural and Irish Cobbler were used. The experiments were designed to produce the following three types of plants: Type 1, plants allowed to set fruit (fruiting plants); Type 2, plants permitted to flower but not set fruit, all flowers being removed approximately three days after opening (flowering, non-fruiting plants); and Type 3, plants treated by the removal of all flower clusters in the bud stage (non-flowering, non-fruiting plants). Both flowering and fruiting caused significant reductions in vegetative growth and tuber yields. Growth of underground parts (stolons plus roots) closely paralleled that of the vines. Fruit formation and tuber production were found to be concurrent processes.

Werner's report (82) gives the results, of experiments with four

varieties of potatoes (Earlaine, Triumph 12, Minn. 29.32-1-34, and Katahdin) to determine the relative effectiveness for seed production in the greenhouse of different intensities of supplemental light with 18 and 24-hour photoperiods, of intermittent use of long photoperiods and of continuous light. It was found that a long photoperiod is essential to induce satisfactory seed production with Triumph and other varieties that do not bloom readily. Seed production is improved by using relatively intense supplemental light. The increased intensity of supplemental light is more important when natural daylight is inferior in quality and of short duration. A very long photoperiod with very bright supplemental light can be depended upon to produce flowers and seed.

Handling and Shipping

Barger, Ramsey, Perry and MacGillivray (4) have studied the handling and shipping of White Rose potatoes from Kern County, California, for a period of 3 years, giving special attention to various handling practices and different methods of refrigeration. In shipping tests, the various transit conditions included: 1, ventilation; 2, precooling with portable blowers in pre-iced cars; 3, precooling with ice water before loading in dry cars; and 4, immediate and deferred initial icing of the cars after they had been loaded. In the holding tests, new potatoes were skinned at the bud end and were stored for a week at two temperature ranges and two humidities. Some lots were stored immediately after skinning, some were exposed to wind for a short time before storing, some were protected from the wind with canvas. After storage the potatoes were inspected for surface browning, decay and loss of weight. The results indicated that the best carrying quality of Kern County new potatoes would result from the digging of relatively mature stock, morning digging, immediate pick-up in sacks and by truck in the field, the use of tarpaulins over the load during hauling to the washing shed, and shipping under refrigeration. The hydrocooling of the tubers in ice water to approximately 50° F., followed by immediate icing of the car, controlled discoloration and decay and gave the best results of any of the test shipments.

Poole and Barr (69) published data on a study of precooling and drying methods for Louisiana washed potatoes, to determine the best precooling temperature for shipment, and to work out a low-cost economical method of drying and cooling potatoes. Approximately 60 per cent of the Louisiana potato crop is washed before shipment, and difficulty had been experienced with deterioration in transit. It was

found that the method of digging and handling potatoes in the field was responsible for some decay in transit. The potato digger cut and bruised fewer potatoes than did the middle-breaker. Crates were better containers than sacks for hauling potatoes from the field without bruising. Some shippers were found to be using very inefficient methods for precooling and drying. A design for an efficient bunker-fan unit for precooling and drying potatoes was presented. Mechanical refrigeration units had a lower air delivery than the bunker-fan units, but the latter showed a more even temperature distribution throughout the car. A more thorough job of drying resulted when bunker-fan units were operated while the car was being loaded before adding ice to the bunkers. When using fans to precool with the method of car loading now in favor, lower temperatures in the doorway can be obtained by placing two sacks of potatoes in the aisle leading from the bunker. Greater moisture loss was obtained from crates than from sacks during precooling by the bunker-fan methods. It was not advisable to have a potato temperature below 55° F. when shipping under standard conditions.

Belkengren and Cieslak (7) show that washing potatoes prior to shipping permits a careful inspection of the tubers and the rejection of defects. Since the loading of potatoes in the wet state resulted in considerable rot during transit, the practice has been to pass them through a hot air chamber. Investigation revealed that the beneficial effects were not due to the absence of organisms but rather to the increased suberization promoted by the higher temperature. Slides prepared from tissue cut from the surface showed that this increased resistance to infection was due to the increased number of cells in the periderm layer. Some thickening of the phellem was also noticed. Exposing the tubers to 78.5° C. for 4 minutes gave better results than an exposeure to 68° C. for 8 minutes.

Brentzel (11) records data showing that the treatment of potato tubers affected by Rhizoctonia with 5 per cent solution of $CaCl_2$ for 1 hour effectively removed the sclerotia and imparted a brighter, cleaner appearance to the tubers without causing injury or affecting subsequent sprouting. Brentzel (12) also found that treatment of potato sacks with sodium hydroxide and sodium hypochlorite was an effective way to prevent the spread of bacterial ring rot.

Fox (39), in Kansas, found no outstanding difference in the storage shrinkage of washed and unwashed potatoes of the No. 1 grade. Chippewa and Early Ohio shrank most and Cobbler least, with Warba, Triumph and Mesaba intermediate. In Kansas during the storage period from August to January the least shrinkage occurred in cotton bags, the most in open mesh bags, with burlap bags intermediate.

Storage

Guthrie (42) found that sprouting of non-dormant potato tubers was inhibited by treating cut pieces with solutions of 250 mgs. or more per liter of the potassium salt of 3-indoleacetic acid for 2 days or more at 10° C. When applied in concentrations of 20 mgs. or more of the K salt for 1 day or more, alphanaphthaleneacetic acid inhibited the sprouting of cut pieces of tuber, thus being more than 10 times as effective as indoleacetic acid. Pieces of tuber, the sprouting of which had been inhibited by the K salt of naphthaleneacetic acid, were made to sprout promptly by treating with ethylene chlorhydrin, but potassium thiocyanate had little effect. Sprouting of whole tubers was inhibited by exposure to vapors of the methyl or ethylesters of naphthaleneacetic acid. The volatility of the methyl ester at 10° C. was demonstrated by production of epinasty in tomato leaves. The buds of whole tubers, the sprouting of which had been inhibited by this vapor, were induced to sprout promptly by treating with the vapor of ethylene chlorhydrin. Exposure to the vapor of the methyl ester above noted, also retarded the withering of the uncut tuber. Treatment with the vapor of acetonitrile induced considerable inhibition of sprouting in the whole tuber. Treating cut seed pieces of tubers with the K salt of indoleacetic acid (250-1000 mgs. per liter for 2 hours at 10° C.) induced roots to grow at the cut surface in 11 to 24 days, roots being developed on pieces cut from the center of tubers without skin or eyes. Naphthaleneacetic acid induced rooting at the cut surface of tubers less promptly, but it was active in much lower concentrations. Indoleacetic acid induced rooting sooner and more completely in old or non-dormant tubers than in newly harvested or dormant ones. Breaking the dormancy of freshly harvested tubers with ethylene chlorhydrin caused them to root more readily when treated with indoleacetic acid. Treating freshly harvested tubers with the former increased the amount of auxin extracted from the tissue by a modified du-Buy procedure, but had no effect on the amount extracted by the van Overbeek method. Indoleacetic acid failed to break the dormancy of freshly harvested tubers. It inhibited sprouting at high concentration, but there was indication of a very slight stimulation at the low concentrations. Considered as a whole, the results of these studies offer little support to the idea that the dormancy of potato tubers is regulated by increase or decrease in the amount of auxin-like substances in the tissues.

Guthrie (43) also reported that treatment of freshly harvested potato tubers with solutions of glutathione shortened the rest period,

this effect being about the same as that of ethylene chlorhydrin treatments inducing a similar glutathione content of the tissues. It thus appears that the ethylene chlorhydrin treatment breaks the rest period by increasing the glutathione content of the tissues.

Denny, Guthrie and Thornton (24) in their tests, found that the methyl ester of alphanaphthaleneacetic acid when incorporated into filter papers which were distributed among potato tubers stored in earthenware containers, inhibited the sprouting of the tubers. Four hundred mg/kg completely inhibited the sprouting for one year; with 100 mg/kg there was a small amount of sprouting after 6 to 8 months; 30 mg/kg definitely retarded sprouts and the lowest limit was 10 mg. The jars were not tightly closed but merely had papers over them. Filter papers, once used, were effective a second time in closed containers. At 10° C., tubers were stored for 1 year without shrinking or sprouting. At 15° C. there was some shrinkage but no sprouts for 8 months. At 18° C. sprouts were inhibited for 3 to 6 months but some shrivelling occurred. No relation was established between the treatment and the sugar content of the tubers. Treated stored tubers produced good chips but it is not known how much of the chemical was in the tubers so the method was not recommended for commercial use.

Denny (23) conducted experiments on inhibiting sprouting in storage of Cobbler tubers by the use of the methyl ester of alphanaphthaleneacetic acid. Denny's experiments are an extension of those reported by Guthrie in 1939. Tubers in lots of 20 bushels, placed in wooden bins shortly after harvest were exposed to the vapor of the ester incorporated into paper towels which were interspersed evenly among the tubers in the bins. An amount of the methyl ester equivalent to 50 to 100 mg/kg of tubers completely inhibited sprouting from the 3d of October to the 6th of May. Only a few sprouts were formed by tubers treated with 33 mg/kg. Control tubers sprouted freely under the same conditions. Later tests, using talcum powder as a carrier, indicated that when the chemical was distributed over the surface of the tubers in this medium the amount required could be reduced to 25 mg/kg. Other carriers as confetti and chopped dried plant residues were given preliminary tests. The amount of chemical which was absorbed by the tissue was estimated by a hyponasty test using the tips of young potato plants as indicators of the presence of the vapor of the methyl ester. Hyponasty of the upper leaves of the potato cutting was observed within 4 hours when the amount of the methyl ester incorporated into filter papers was as low as 0.02 to 0.01 mgs. in a closed container, having a volume of 1 liter. By extracting the weighted amount

of the treated tissue with acetone, transferring the extracted methyl ester to filter papers, placing such impregnated papers in closed vessels with potato tips and comparing the response with that obtained with papers containing known amounts of methyl ester, an estimate of the amounts in the sample of potato tissue was obtained. These measurements indicated that the amount of methyl ester taken up by the tissue of tubers treated 5 months with an amount of ester equivalent to 100 mg/kg tubers was not more than 5 mgs. methyl ester per kg. of tissue of which at least 4/5 was in or on the skin. After 5 months treatment the tubers did not germinate satisfactorily when cut and planted, nor even when treated with ethylene chlorhydrin. When these tubers were first washed thoroughly with soap and water, the ethylene chlorhydrin treatment was more successful,—especially when the amount of ester used was low. The dormancy of tubers inhibited wth the methyl ester seems to be deeper than that which occurs in tubers at any stage of the natural rest period.

Durham (33) describes methods used in England to prevent the annual wastage of stored potatoes through sprouting. The means suggested are the use of late-sprouting varieties such as Sutton's Fir Apple and the French variety Rose and procedures to prevent premature sprouting. It is suggested that exposing the tubers on the ground before storing for 2 days might be effective in delaying sprouting. Killing the eyes by immersion in a 10 to 15 per cent solution $NaClO_3$ was a promising method but preliminary experiments have shown that a non-toxic antiseptic is also needed to control an increased susceptibility to fungus disease.

Keith (49) has described storage sheds which have proven satisfactory as successors to the ancient British method of storage outdoors in "clamps, pits or graves." Depth of piling, cold protection and storage disease prevention are also considered.

Karmarkar and Joshi (48) have been searching for ways to store both seed and table crop potatoes through the hot season on the plains of India, where much trouble was experienced with shrinkage, insects and disease and early breaking of dormancy in common storage. Below 35° F., dormancy was indefinitely prolonged. At 40° F. the maximum period of dormancy was nine months. Any delay in placing potatoes at this temperature after harvest reduced the period of dormancy. There was no loss in storage at 40° F. or 35° F., but at lower temperatures, 30° and 32° F., the potatoes were injured by blackheart after three months' exposure. The sprouting vigor of the potatoes was not affected by extending the rest-period at temperatures of 35° and 40° F. There

was some indication that the yield was favorably affected by storage at these temperatures. When black-hearted potatoes were used as seed, they rotted completely.

In 1939-'41 Parsons (66) obtained data on shrinkage and deterioration of potatoes in cold storage. Relationships between humidity, temperatures, and evaporation in relation to shrinkage and deterioration were observed in separate cold storage rooms. Deterioration and shrinkage during cold storage were severe where decay and sun damage were among the tuber defects. Since about one-half the total shrinkage of good potatoes in cold storage over a 6-month period will occur during the first few weeks, sacks of potatoes should contain from 103 to 106 pounds (depending on the storage period) if the marketing of 100-pound sacks of potatoes of storage is desired. With ideal cold storage conditions and U. S. No. 1 potatoes, the use of closely woven cotton sacks will decrease the weight shrinkage compared with potatoes in burlap or open-mesh sacks. Where the quality is uniformly good, shrinkage in weight of washed and clean unwashed potatoes is about the same, whereas washed potatoes of low grade shrink more and deteriorate faster than unwashed potatoes in cold storage. Triumphs shrank slightly less than Cobblers. Ultraviolet ray treatment had no effect on the keeping quality of potatoes with the more common defects. For best results, potatoes evidently should be placed in cold storage rooms where the circulation of air is sufficient to prevent condensation of moisture on the tubers after the first week or two of storage. Less shrinkage and minimum deterioration will occur if the relative humidity remains fairly uniform at from 85 to 90 per cent. The most satisfactory cold storage temperature for potatoes is near 45° F. Temperatures below 40° F. over a long period may cause changes in flavor.

Hilborn (45) has found that internal mahogany browning of potatoes is caused by low temperature and Reiner Bonde has found that the reduction in yield of Katahdin and Chippewa is related to the severity of this defect in seed.

Hardenburg (44) has discovered a rare abnormality in stored potato tubers of the Bliss Triumph variety which consisted of a vigorous development of internal roots. These roots developed mainly in the inner medullary region and in no case did they penetrate the epidermis and appear externally, although there were swellings plainly indicating their presence beneath the skin. The development of this condition is attributed to the dry, warm conditions of the place where the tubers were stored.

McKay and Clinch (53) conducted laboratory experiments on

freezing injury to stored potatoes. They found great differences in the resistance of individual tubers to low temperatures. Of tubers exposed to 17° F. for 18 hours, the majority were complete "leakers" while some were uninjured. Of tubers exposed to 17° F. for 4 to 6 hours, the majority showed a dry type of injury such as internal necrosis and mealiness, and more or less killing of eyes; the tubers exposed to 17° F. for 2 hours were uninjured; those exposed to 28 to 30° F. for 18 hours and 72 hours were uninjured; and tubers with tough skins and short leafy sprouts, treated on the 1st of April were more resistant than those of the same batch examined 4 months previously. When planted, tubers that had been frost-injured, formed tubers prematurely.

Denny and Thornton (25) seeking a means of producing light-colored potato chips, stored 16 tuber samples of Cobbler potatoes under various conditions; two temperatures and three concentrations of CO_2 for one month after which samples were taken for sugar determinations. The results showed that the rapid increase in reducing sugar which occurs in potato tubers stored at 5° C. was prevented by storing the tubers in an atmosphere containing 5 per cent CO_2. At the end of 2 months at 5° C. the reducing sugar content of the CO_2-treated lot was 1/5 that of the control in air. A second report on this work has appeared (26). The previous experiments were extended to include a wider range of gas concentrations and more varieties, as well as longer storage periods. Potato tubers were stored at 2°, 5° and 7° C. in atmospheres containing 0, 5 and 20 per cent CO_2 and 21 per cent O_2. At intervals of 30, 50 and 90 days, samples were removed for the determination of the reducing sugar and sucrose contents of the juice, and for the preparation of potato chips. A retarding effect of 5 per cent CO_2 was also obtained at 7° C. Treatment with 20 per cent CO_2, although exerting a retarding effect over a period of 30 days at 5° and 7°, then had the reverse effect, so that at the end of 90 days at 5° the reducing sugar values were equal to the controls, and at 7° were 3 to 5 times those receiving no CO_2.

Denny and Thornton (27) report experiments in which tubers of 25 varieties of potatoes with known history from harvest to storage were stored at temperatures of 5°, 7° and 8.2° C. for varying lengths of time at each temperature,—storage starting at two intervals after harvest, *i. e.*, one series on the 25th of October and the other on the 24th of December in order to determine the sugar-forming characteristics of the tubers in cold storage and their suitability for the production of potato chips. Confirmation of the previously reported fact, that the concentration of reducing sugars and not of sucrose determined the color

of potato chips obtained. Potatoes with more than 5 mgs. of reducing sugar per cc. of expressed juice made the chips too dark in color. For satisfactory commercial use the reducing sugar content should be as low as 3 mgm/cc. The sugar content of a given variety did not change much between different crops. The reducing sugars were lowest when the tubers were stored at 8.2° C. but sprouting was so extensive, that 7° C. was considered the most favorable for chip manufacture. Delaying the start of storage retarded the rate of increase of reducing sugars and lowered the ultimate valued attained. The varieties best for chip manufacture were: 1, those of the Rural group; 2, Blue Victor; 3, Chippewa; and 4, Cobbler. Unsuited varieties were Eureka, Green Mountain, Delaware, Bliss Triumph, Prde of Multnomah, Spaulding Rose, Blue Mercer, Warba and Axtell's Bugless. Changes in sucrose content among the 3 temperatures produced less effect than the changes in reducing sugar at the corresponding changes in temperature. A temperature difference of 1° C. was found to be sufficient to show significant changes in the amount of reducing sugar and sucrose. Locality and soil conditions had little effect on the amounts of reducing sugars developed during cold storage. A report on a third year's work on the same subject (28) emphasizes that to obtain light-colored potato chips the potato juice should not contain more than 3 mgs. of reducing sugars per cc. With the nineteen varieties tested, contnuous storage at 5° led to the accumulation of reducing sugar in amounts much higher than 3 mg/cc. Storage at 7° gave lower values for reducing sugars, and at 8° still lower,—usually below 3 mg/cc.

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SECTIONAL NOTES

Alabama

The South Alabama potato section has had a most variable season. This planting season has been one of the most favorable in years. Soil moisture was ideal for planting. Rainfall and temperature were ideal for rapid development of the crop in February and during March. A light frost in March, however, did very little damage, but the low temperatures in April retarded the crop. Rainfall was excessive during the latter part of March and early April. In the extremely lower part of the county (Baldwin) blight has caused considerable loss. At this time uneasiness is expressed regarding the spread of the disease to other parts of the section, depending upon continued unfavorable weather.

Sufficient labor was available for planting and will be adequate for growing the crop. It is expected, however, that the matter of

finding adequate labor for harvesting this year's acreage will present some difficulty. Plans are now being made to locate and have available for the harvest season enough labor to handle the crop. War prisoners are expected to assist in our harvesting operations.

Plans are developing whereby boys from city schools will also be available for work in the grading and packing sheds.

The earlier estimates of 24,000 acres for South Alabama have been fully realized.

It is expected that growers will be satisfied with the ceiling price of $2.40 per hundred established by the OPA. (April 7)—L. M. WARE.

CALIFORNIA

It now appears that we will be definitely marketing potatoes only from 50,000 acres in Kern County in the floor of the valley prior to the 20th. At this date there has been no ceiling set on potatoes. There has been, however, a support price schedule set up by the War Food Administration which starts at $2.20 per hundred f. o. b. car for U. S. No. 1 potatoes. Varying prices have been scheduled for other grades, and a reduction has also been established as the season advances as far as the support price is concerned, going as low as $1.95 in July.

Carlot shipments of potatoes in 1943 from Kern County which included truck and rail were as follows:

Week ending	Cars Marketed (Truck & Rail, 1943)
April 2	0
April 9	5
April 16	55
April 23	517
April 30	965
May 7	1,407
May 14	1,603
May 21	2,028
May 28	2,882
June 4	3,266
June 11	3,211
June 18	3,144
June 25	2,363
July 2	1,051
July 9	326
July 16	75
July 23	12

I merely present the above figures to give a pattern of the shipments of potatoes in 1943. In 1944 our shipments will not be so heavy at first, despite the increased acreage. This is due primarily to a setback caused by the frost during the middle of March. However, we expect the shipments to reach more than 4,000 acres per week by the 1st of May and early June. This increase in shipment as compared with 1943, of course, is due to approximately a 14,000-acre increase in the floor of the valley, in addition to the delayed harvest in the early part of the season caused by frost which will set back probably 25 per cent of the crop.

The year 1944 is not expected to be so profitable for the potato growers as the year 1943. However, generally speaking, the growers feel confident that the market will not be too disastrous. Some growers have even indicated that this potato season will be more profitable to a certain extent than that of 1943. This, of course, will depend upon the yield as well as what the yield will be from competing areas, and the stock of old potatoes that will be going on the market to compete with our supply. The yield for each acre marketed in 1943 for all grades of potatoes actually sold was 214, 100-pound sacks per acre. We will probably have a yield slightly less in 1944 for two outstanding reasons. A large number of new growers who are not experienced in the production of potatoes, and the reduction of yield that will be caused by the frost. Some growers will also be handicapped in production because of poor quality seed which, however, is not one of the major factors as we see it today. (April 7)—M. A. LINDSAY.

IDAHO

Idaho is getting close to the end of its potatoes left for shipment this spring. The two or three thousand cars that remain for shipment may hold out for quite a period, as sorter crews, which have been largely composed of farmers, are disbanded to go back to farm work. With the exception of a period when the No. 2 market was dull, the demand for Idaho potatoes has been good, and prices have been close to ceiling during most of the marketing season. It has not been necessary for the government to purchase potatoes in Idaho to maintain price supports, for recently the market has been especially strong.

All certified seed has been contracted and will move at ceiling prices for the most part. An increase in acreages to be inspected for certification coming both from old growers and new growers, including some in new areas, is in prospect. The total acreage may vary from five to six thousand.

Idaho's commercial acreage for 1944 will probably be 20 to 25,000 acres less than the all-high average of 197,000 planted last year. Dealers and growers are reporting a slow market on "one year-out" seed. Labor, machinery and water shortages are affecting growers' plans to some extent. At least one new area of commercial production in one of the higher mountain valleys of the state will enter the picture this season. There will be little need for additional storage this year except in a few isolated cases.

Potato growers' educational meetings have been well attended this winter, and their interest in Idaho's potato research program is exceptionally strong. (April 3)—EUGENE W. WHITEMAN.

INDIANA

The markets are still glutted with old potatoes and new potatoes are being shipped to us from the south. The price is holding up well for table stock. There seems to be an ample supply of good seed potatoes of the standard and newer varieties. There is also a large demand for the Sebago and Sequoia varieties. The commercial acreage in the southern part of our state will be planted this month; some are already planted,—but the bulk of the spot sales and future orders will go to our Hoosier gardeners, who will plant during the latter part of this month and the first part of May. (April 5)—W. B. WARD.

NEBRASKA

No up-to-date information is available regarding the planting in early sections of Nebraska. In the usual season, growers will be beginning to plant in the Kearney-Gibbon and Burwell Arcadia sections. Owing to considerable moisture, both snow and rain, during the past few weeks, planting has been held up somewhat,—awaiting proper ground conditions.

The writer has just returned from checking of southern test plots in Baldwin County, Alabama. A month ago, similar plots were checked in the lower Rio Grande Valley, adjacent to Brownsville, Texas.

The Texas plots are reported practically matured, because of heavy infection of Late Blight. A Late Blight infection is well distributed over the Rio Grande Valley, and at last report is presumed to have reduced the yield at least 50 per cent.

On the 5th of April a survey of Baldwin County, Alabama, revealed that Late Blight was well established in the earlier-planted areas in the vicinity of Elberta. Numerous fields that were visited were found to be affected with Late Blight, and the damage in an occasional

field was readily visible while driving on the highway. Conditions for the spread of this disease were favorable, but were subject to change from day to day. In the heavily infected areas, the disease could be expected to continue to advance, regardless of conditions. Slight infections were found in the later planted areas about Fairhope, Loxley and Robertsdale. Favorable growing conditions or conversely, unfavorable conditions for the disease, should result in good yields in that territory. It is reliably estimated that at least 30 per cent reduction above our original prospects could be expected. Some of this loss was occasioned by excessive rains, which packed the ground and leached the fertilizer. A further reduction in the condition of the crop was not expected, however, since weather conditions were the controlling factor.

Conditions in western Nebraska are favorable from the standpoint of moisture. A good snowfall during the past month, and an occasional rain, has put top soil in very good condition. This is encouraging the dry land growers who were faced with very poor prospects at the beginning of the winter. It is entirely too early to estimate probable planting,—however, little increase in the acreage above that of last year is expected.

Potatoes of Grade U. S. 2 or lower, are being diverted from regular channels. These are being loaded in gondolas, or coal cars, unsacked, taken to sugar factories, where they are sliced and dehydrated. The final product will be used as stock feed, where it is offered for sale at approximately $42.00 per ton. It has been tried, we understand successfully, at an alcohol conversion plant, along with grains. A plant of this type was recently opened at Omaha, and is now in full operation.

The shipping of table stock is rapidly drawing to a close because sprouting of the tubers renders them highly unsatisfactory. Quite a few local seed deals are still being consummated.

A general potato improvement program is being launched by the Nebraska Potato Improvement Association. Railroads, potato dealers and farmers have contributed to a fund for this purpose. Phillip A. Hoff, recently Superintendent of the canning factory at Scottsbluff, and formerly Assistant Certification Manager with the Nebraska Certified Potato Growers, has been chosen to direct this program. Growers' meetings, radio talks, and distribution of literature, are among the means being taken to promote general improvement of the potato industry in Nebraska. (Apr. 13)—MARX KOEHNKE.


TREATING SEEDS
SAVES
CROPS AND
DOLLARS
Control
SCAB and
RHIZOCTONIA
by using
WOOD RIDGE AGRICULTURAL
YELLOW OXIDE of MERCURY,
CORROSIVE SUBLIMATE
and CALOMEL!
WRITE FOR PRICES AND LITERATURE
CONTAINING FULL DIRECTIONS FOR TREATING
SEED POTATOES AND SOIL DISINFECTION.
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NEW JERSEY

The planting of New Jersey's potato crop is only about 60 per cent completed, because of the very cool, wet spring. Usually, at this time, 75 to 80 per cent of the crop is in the ground. It is doubtful whether or not the major portion of our crop will be planted before the 6th of May. On account of the lateness of the season, some growers have decided not to plant so large an acreage as they had previously planned

A number of cars of old potatoes are still in storage. The off-grade potatoes are being purchased by the Commodity Credit Corporation for the manufacturing of industrial alcohol, and for use in feed (Apr. 24)—J. C. CAMPBELL.

OREGON

Preliminary intentions to plant indicate an acreage about the same, or slightly less than last year. Certified seed is in great demand, and the Oregon certified seed is difficult to get.

Shipments to the 1st of April were approximately 9,500 cars in the Klamath district. A rough estimate of 500 to 700 cars is still left on hand. (April 4)—C. A. HENDERSON.

NORTH CAROLINA

"I have been growing potatoes for thirty-five years and this planting season has been the worst I can remember." This remark was made while talking with a grower this week. It gives the story in a nut shell. The crop is usually in the ground by the 10th of March, but some growers could not finish planting until this week, and many began re-planting because of seed piece decay. The decaying of seed pieces has been rather general, and, naturally, much more serious in some sections than in others.

The rainfall was excessive during the latter part of February and throughout the month of March. Growers took advantage of every break in the weather, but rain rarely held up long enough for the soil to get in good planting condition.

Preliminary estimates indicated that about 35,000 acres would be planted in the early belt in 1944. Although it is difficult to judge at this time, it is believed that the acreage will be considerably less than this figure. The possible reduction in anticipated acreage and poor stands in some areas, may finally result in the smallest crop of early potatoes in North Carolina in recent years. (April 7)—M. E. GARDNER.

South Carolina

The prospects for the potato crop in South Carolina are the poorest on record because of excessive rains and a late spring freeze.

Approximately 50 per cent of the seed potatoes were planted during favorable weather prior to the 10th of February. All potato seed pieces in low spots in fields rotted in the soil following the rains of 1.25 inches on the 12th of February and 4.35 inches on the 15th. Most soils were water-logged from the 12th of February until the early part of April. About one-half of the acreage was replanted in wet soil during the latter part of February or the middle of March Practically all those that were replanted rotted before emerging. Rains of 2.97, 1.96, 0.67, 3.65, and 1.07 inches on the 7th, 11th, 20th, 23d, and 25th of March, respectively, in addition to showers interspersed between these dates made a total rainfall of 11.32 inches for March. This rainy period was followed by 6.85 inches in February. (The average monthly rainfall for February and March is three (3″) inches). Some potatoes were planted as late as the 10th of April. In most years, potatoes planted after the 1st of March produce extremely low yields. It is estimated that not more than 50 per cent of the expected acreage of potatoes emerged. A broken stand is found in nearly all fields.

The late frost and low temperatures (Min. 29°) that occurred on the 7th of April nearly ruined the potato crop. Plants in most fields were about six (6″) inches high and were practically killed to the ground.

Even if favorable weather prevails from now on, the potato crop will not be more than 25 or 30 per cent of normal. Therefore, at present ceiling prices the growers will probably lose thousands and thousands of dollars,—for the cost of planting an acre of potatoes this season was about $100.00. Much of the acreage has been replanted once and some of it twice, at an additional cost, varying from $50.00 to $100.00. The growers think that the ceiling price should be raised to that of South Florida. Even then, most of them will suffer a great loss on their potato crop. (April 11)—C. N. Clayton.

Errata

In the March issue, in the Article entitled, "The Effect of Different Amounts of Spindle Tuber and Leaf Roll on Yields of Irish Potato" by E. L. Le Clerg *et al*, on page 61 under the second heading, the sub-head "Leaf Roll" should appear; on page 62, line 3, the sentence should read, "Occasionally the tubers have a pronounced constriction, etc.", instead of "Frequently the tubers have a pronounced constriction, etc."

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POTATO PRODUCTION PROBLEMS IN CHINA

T. P. Dykstra

United States Department of State, Chungking, China

FOREWORD

Prior to 1942, the Chinese Government asked the United States to send a number of specialists in various agricultural lines to China to assist them in putting their food-production program on a sound basis. Among the men desired was a potato specialist, who could help Chinese agricultural workers in setting up a sound improvement program with this crop.

Recognizing the importance of the potato problem in China, officials of the United States Department of Agriculture recommended to the Department of State that Dr. Theodore P. Dykstra be assigned to this enterprise. Dr. Dykstra has a world-wide knowledge of potato diseases and methods of controlling them, as well as being thoroughly familiar with potato breeding and improvement methods. Dr. Dykstra's services were subsequently made available to the Department of State, and he left for China in September 1942. He is doing a splendid job on the assignment, as may be realized from the brief report made in this article. He expects to return to this country in the late summer of 1944. J. R. M.

After an eventful and interesting trip of approximately 3 months, traveling 12,000 miles by water and 10,000 by air, I arrived in Chungking on the 10th of December, 1942, where I spent about 2 weeks making official calls and attending numerous conferences, dinners, and luncheons. Then I left for Pehpei, a village of 2,000 inhabitants, 50 miles north of Chungking, to join the National Agricultural Research Bureau. This Bureau had been evacuated from Nanking in 1937 and moved to a number of different localities before it became established in Pehpei, Szechwan, in 1942. A number of other scientific institutions and one universty, all from occupied territory, are also located here. On account of war conditions and the recent establishment of the Bureau in this town, facilities were meagre. However, esprit de corps made up for scarcity of essential equipment. Most of the senior technicians connected

*Technical Expert under Cultural Relations.

with the Bureau have had advanced training in America or in England. They had left Nanking where excellent equipment and working facilities were available. Some of the equipment and books had been saved, but much had been lost. Practically all these people had lost most of their personal belongings and had left comfortable homes. Pehpei was merely a town in the interior of Western China, totally unprepared for the influx from occupied territory. Housing problems were acute, and any place that provided shelter was welcome and transformed into a home. The cost of living was rising about 10 per cent a month, and on account of inflation the salaries provided only a bare existence. Never did I hear any member of the staff complain. A typical expression was: "This is wartime; as long as we can retain our health, that is all we ask." The Chinese are a realistic people and dare to face difficulties and make the best of them, with confidence that better times are in the offing.

I have elaborated somewhat on these admirable characteristics of the Chinese people, because it seems to me that an understanding and appreciation of these qualities is necessary to any Westerner who comes to China. When he sees the many difficulties to be overcome he may become discouraged and feel that some of the obstacles are insurmountable, but the spirit of the Chinese people is such that there is no need to feel discouraged.

No time was lost in getting the national potato program under way. Dr. C. C. Kwan was designated as leader, and by training, experience, and personality is admirably qualified. Dr. Kwan returned from America in 1933, where he had spent four years at Cornell Univeristy as a graduate student,—majoring in horticulture. While there he came under the influence of Dr. J. R. Livermore, who inspired him with the possibilities of potato improvement. After returning to China, Dr. Kwan not only conducted investigations on this crop, but also occupied the position of professor of horticulture at the University of Nanking, and later in the Agricultural Research Bureau at Kweiyang, Kweichow. It was undoubtedly Dr. Kwan's perseverance and his realization of the possibilties of the development of a national potato research program in China that influenced the Chinese Government to request the American Government for aid in developing such a program.

Mr. H. T. Yang, a member of the Szechwan Provincial Agricultural Improvement Station at Chengtu, came to Pehpei in February 1943 to be associated with the potato program. Mr. Yang is a former student of Dr. F. A. Krantz at the Universty of Minnesota, and while there in 1940 he became interested in potato breeding problems. Mr. C. R. Chiang, a 1937 graduate of the School of Agriculture of the Uni-

versity of Nanking, was also assigned to this project. These men have a speaking knowledge of English and are keenly interested in the work.

In consultation with the director and other officials of the Bureau a program for the year was prepared. Included in this program were the following investigations:

1. Planting true seed and growing and testing the progenies.
2. Testing commercial varieties brought from America.
3. Indexing about 10,000 tubers obtained from different provinces in China for presence of tuber-borne diseases.
4. Sending a questionnaire to officials of provincial experiment stations to obtain data on the importance and the problems of the potato industry.
5. Making a national survey of the potato industry.

True seed of the various breeding lines brought from America was planted at Pehpei during the first week of January. In the absence of a greenhouse a cold-frame was used. On account of the cold and cloudy days, which are characteristic of the weather during the winter months in Szechwan, germination of the seedlings was delayed. Five thousand seedlings were transplanted in 3-inch pots durng the middle and the latter part of March. They were harvested during August, but on account of the excessively high temperatures prevailing during the summer practically no tuberization had taken place. This demonstrated that this location is not suitable for the growing of seedlings, and in the future they will be planted in an area where climatic conditions are more favorable.

The 52 commercial varieties brought from America were planted in 3 different regions of China, namely, the provinces of Szechwan, Kweichow, and Shensi, representing Central, Southwest, and Northwest China, respectively. In order that the instructions about planting these varieties would be followed carefully, they were planted in localities where experienced personnel was available. Accordingly, Pehpei in Szechwan, Kweiyang in Kweichow, and Wukung in Shensi were selected. But, as found out later, these locations were not ideal from the standpoint of optimum conditions for potato development. The varieties Sebago, Warba, Chippewa, and Houma were very promising from the standpoint of yield and shape of tubers as compared with the locally grown varieties. Warba appeared to be especially promising at Kweiyang, Kweichow. It not only produced a large yield but matured much earlier than the local varieties. Climatic conditions at Kweiyang are suitable for the growing of two potato crops each season, and since the

Warba has a short rest period, tubers from the spring crop can be used to plant the fall crop. Since these 4 varieties were outstanding in yield in each of the 3 regions in which tested, a request was sent to America for the shipment of 100 pounds of each. It is realized, of course, that a 1-year test is not sufficient to determine the adaptabilty of a potato variety to a certain region, but the performance of each one of these varieties was so outstanding that we felt a start should be made to increase seed stocks of them. The varieties have been shipped and should be in Chungking before the planting season starts.

In order to determine the amount and type of virus diseases present in the potatoes grown in China, as well as the possibilty of obtaining a supply of disease-free seed tubers, a request was sent to officials of different provincial experiment stations to supply 1,000 tuber indexes. A total of 8,000 indexes were received from the provinces Szechwan, Yunnan, Kweichow, Honan, Hupeh, Shensi, and Kansu, and these were planted at the experimental farm at Pehpei. The indexes were taken from tubers obtained in different hsiens (counties) in each province. Their performance indicated that practically all tubers tested were infected with some virus disease. Leafroll was the most common one. Small amounts of rugose mosaic, mild mosaic, and spindle sprout were also found. Since practically 100 per cent of the plants had virus infection, none of the lots could be used as a source of virus-free seed. These samples of potatoes, taken at random from practically every important potato-growing province in Free China, demonstrated conclusively the prevalence and seriousness of potato virus diseases in China.

The replies in the questionnaire sent to agricultural scientists of different provincial experiment stations showed that in some provinces, especially in the Northwest, the potato is an important crop. In Kweichow, Szechwan, Shensi and Kansu some experimental work has been conducted on such problems as date of planting, effect of ridging, clonal selection, and potato breeding. Practically nothing is known about varieties except that they are white-skinned or red-skinned. The identity of the original varieties has been lost and when varietal names are now used, they are provided by officials of experiment stations, who find it convenient to differentiate varieties which may have been used in different tests. Farmers generally select the small tubers for seed and use the larger ones for the table. Late blight, early blight, blackleg, virus disease, and rots were mentioned as the most important diseases. With the exception of spraying for the control of late blight in areas where copper sulfate is available, practically nothing is being done to control

diseases. Storage facilities were reported to be inadequate, and as a result storage rots caused considerable losses.

The Chinese Government purchased a 1941 Ford sedan to help in the survey of potato fields in the different provinces. In Szechwan and Kweichow Provinces the group consisted of a driver, who also served as a mechanic, Dr. C. C. Kwan, Mr. H. T. Yang, Mr. C. K. Chiang, and myself.

The potato-growing district of Penghsien, Szechwan, was inspected in May. About 25,000 acres are planted to potatoes in this area where the elevation and climatic conditions seem to be ideal for successful potato production. Potato fields near the city of Penghsien were inspected the first day, and all the plants observed were infected with leafroll. A considerable amount of rugose mosaic was also noticed. Several days were spent in the mountains where practically all the potatoes inspected showed leafroll, and a high percentage of them also showed rugose mosaic. Aphids, apparently *Myzus persicae,* an effective carrier of virus diseases, were commonly found on potato foliage. It was hoped that a field might be located which was comparatively free from the virus disease, but none was found. In a different section of this area near the top of a mountain we found a small field, in which every plant seemed to be free from the virus disease. Upon inquiry it was learned that the owner of this field had been saving his own seed for more than 10 years. Apparently the original lot was virus-free, and since the field was isolated the potatoes remained healthy. Arrangements were made to buy the entire crop. Next year these tubers will be planted in the same area as tuber units to secure a supply of seed potatoes free from viruses.

In June a survey was made of potato-growing districts in Kweichow Province, in the southwestern part of China. The most important potato region of this province is in Weining in the extreme western part of Kweichow. En route to this area we stopped at different places to inspect some of the commercial potato fields. Practically 100 per cent of the plants in the fields inspected had leafroll; in addition, we also found several typical witches'-broom plants. Although practically all fields were heavily infected with leafroll, with some rugose mosaic and mild mosaic, a few fields were practically free from virus. About 17,000 acres of potatoes are located in the vicinity of Weining, which appears to be an ideal potato country. The elevation is 5,000 feet, and the soil is a black muck. It is near the important Kunzing-Chungking highway, and transportation facilties make it possible to ship potatoes from here to non-producing centers. Three varieties are grown in this section. In many fields the varieties were mixed. The growers plant two or three

small tubers in a hill; sometimes two varieties are grown in the same hill. Arrangements were made to buy healthy or nearly healthy seed potatoes of each one of these three varieties to increase for seed production. The county officials have made arrangements to provide land well-isolated from infected potato fields. The potatoes will be planted in tuber units under supervision of technicians from the provincial experiment station. Virus-infected units will be rogued.

In July we started for Northwest China. This territory is still largely undeveloped but has considerable potential resources, and the Government is undertaking many projects to develop this part of China and induce inhabitants from over-populated areas to establish homes here. A fertile loess soil, with practically no subsoil, is the prevailing type. Efforts are being made to increase food production considerably. With sufficient rainfall excellent crops such as millet, glutinous millet, sorghum, buckwheat, soybeans, wheat, hemp, some alfalfa, and Irish potatoes are produced. The grasslands found here provide great possibilities for the development of a livestock industry.

Rice and sweetpotatoes, which are grown extensively in most of the other provinces, are found here only in restricted areas. The acreage devoted to potato growing is increasing every year. This is a major crop and provides the main diet for more than 50 per cent of the population. Many areas are well adapted to the growing of potatoes and during dry years, when other crops failed, the potato crop has maintained the population. In 1943 heavy rains occurred during August and September, which made dirt roads impassable, swelled the rivers, and washed away bridges. This, of course, limited the extent of the survey, but despite this handicap, several important potato districts in Shensi, Kansu, and Chinghai Provinces were inspected. It was necessary to make several trips on horseback.

All our efforts to find a single field of virus-free potatoes failed. Every plant in the inspected fields was infected with leafroll. Occasionally we found a severe infection of rugose mosaic and some current-season infection, but this disease is not nearly so prevalent as leafroll. Spindle sprout was found frequently. Late blight infection was first observed during the early part of August; it had become epidemic by late September. Climatic conditions for the rapid development of late blight were very favorable during the late summer and the fall of 1943. Potatoes planted without ridging and in some cases only 1 foot apart in and between the row provided ideal conditions for the development of this disease. The tubers near the surface of the soil become infected easily from spores washed from blighted foliage by rain. Tuber rot

started sometime before the crop was ready to harvest. It seemed that in some sections this disease might cause nearly 100-per cent tuber rot. Although 1943 was an unusually wet season, rainfall during September is quite common,—often causing a loss of at least 30 per cent of the tubers because of rot. Since spray chemicals and spray equipment are not available in the Northwest, varieties resistant to late blight offer the only possibility of control.

The development of a potato-improvement program was discussed with experiment station workers and provincial government officials in each province visited. It is planned to make one more extensive survey in the Northwest next summer and to cover two additional provinces, namely, Ningshia and Sinkiang (Chinese Turkistan). This will provide additional information on potato problems in this region. Final arrangements will be made for the organization of a much-needed potato-improvement program in each one of the five northwestern Provinces.

The performance of the index plantings at Pehpei and the survey of potato-growing areas in five provinces have demonstrated conclusively the prevalence and seriousness of virus diseases, especially leafroll. The aggregate annual reduction in yield caused by leafroll alone amounts to several million bushels. Fields found to be free from virus were purchased by the Ministry of Agriculture, and the potatoes will be planted as tuber units in isolated fields next year in the same area. The increase from these fields will be purchased, and a larger area will be planted for seed purposes the following year. When a sufficient quantity of disease-free seed potatoes have accumulated, a portion will be distributed to the growers of table stock. Means will be provided to aid seed-potato growers to organize cooperative associations, which can obtain loans from the National Farmers' Bank at a low rate of interest for the construction of well-equipped potato storage houses. Individual farms are small, and the growers cannot afford to invest money in such improvements.

By growing disease-free seed of varieties commonly found in China, it should be possible to double the yield per unit area. If introduced varieties exceed in yield and quality the native-grown varieties, arrangements will be made to import them. These may gradually replace existing inferior varieties. The increase obtained from the 52 American varieties tested during 1943 in 3 sections will be planted in additional areas in 1944. If these tests should prove that Sebago is well adapted to the Northwest, it may become the major variety for this region because of its resistance to late blight.

After a potato-seed industry is established it will be necessary to

develop a seed-certification system. In the meantime, inspectors will have to be trained to recognize disease symptoms and varieties. The regulations for this service will have to suit conditions in China. In general, potato seed certification in China will probably be similar to that in America.

The extensive service will play an important part in disseminating information on potato production problems. Before very much progress can be made in a potato-improvement program, cooperation from the potato growers will be needed. Very few growers have ever seen a healthy potato plant. The rolled leaves and dwarfed appearance are considered typical of normal potato plants. Since practically all the plants in potato fields are infected with leafroll, it will be rather difficult to persuade the growers that all their plants are infected with a serious disease. An educational campaign will be most effective if losses in yield due to virus can be demonstrated by performance of plots planted with both virus-infected and healthy seed.

The potato program in China should be considered, at least during the first few years, as primarily a production program. Many of the urgent problems confronting the potato industry can be solved by making use of available information and by using varieties from foreign countries. For these reasons it is not considered necessary to develop within the next few years an intensive and extensive research program. Projects started now aim to increase production per unit area, increase the area devoted to the growing of potatoes, and also increase consumption. In order to become more familiar with the technique of hybridization and to determine the areas best adapted for this purpose, some potato-breeding projects will be started at once. These projects will gradually expand in those areas most desirable for true seed production and will determine the location of the more extensive breeding work of the future. After a successful potato industry has been established and a more comprehensive understanding of the fundamentals of some of the breeding and pathological problems are recognized, research investigations of a more fundamental nature will be organized. Meanwhile demonstrations on techniques involved in potato breeding, in testing for disease resistance, and in potato disease control will be given. Inspection tours will be made to important potato-growing districts.

Despite the many difficulties that will have to be overcome in order to put a national potato program into effect, there is no doubt that the development of a sound potato industry in China and the organization of an effective potato research program are assured. The prospects for a successful potato program are largely due to the untiring efforts of

several Chinese officials. The Minister of Agriculture and Forestry, Dr. H. L. Shen, has enthusiastically supported the program. Mr. K. S. Sie, director of the National Agricultural Research Bureau, has been most helpful. The Minister of Agriculture and the Minister of Finance, as well as many other prominent government officials, have also taken a sincere and personal interest.

THE DETERMINATION OF VIRUS INFECTIONS IN THE POTATO TUBER BY THE USE OF ULTRAVIOLET LIGHT[1]

JOHN G. MCLEAN AND W. A. KREUTZER
Colorado Agricultural Experiment Station, Fort Collins, Colo.

In the use of ultraviolet light for the determinaton of ring rot in potato seed tubers (2) numerous types of fluorescence were observed which differed in color, location, and intensity from the fluorescence caused by ring rot. Plants grown from such tubers displayed a high percentage of leafroll and other virus diseases, which suggested that the amount of virus infection might be reduced by an examination of cut tubers in ultraviolet light prior to planting, and discarding those showing fluorescence (3).

In order to test this possibility, a lot of potatoes of the Bliss Triumph variety known to contain a relatively large amount of haywire (1) was selected for use as experimental material. To maintain uniform conditions, all the tubers were stored and examined under the ultraviolet light[2] at 40° F. Each potato was cut across near the stem end with a disinfected knife and then examined immediately in ultraviolet light. All other sources of illumination were excluded. More than 1,000 tubers were examined and classified on the basis of their respective fluorescences. These tubers were planted and the resulting plants were read at weekly intervals, from emergence to maturity, for virus symptoms. The tubers which developed from such plants were also examined under the ultraviolet lamp. Only a portion of the data thus obtained can be systematically included in the following tables.

In a preliminary trial, tubers were examined and grouped in four classes based on the degree of fluorescence observed, irrespective of its color or position in the tuber. These classes were: (1) No fluorescence, (2) low, (3) moderate, and (4) intense fluorescence. A summary of the data obtained from field plantings and subsequent greenhouse readings of certain of the progeny is shown in table 1.

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[1]Published as Scientific Series Paper No. 174, Colorado Agricultural Experiment Station, Fort Collins, Colo.

[2]General Electric 220-volt alternating current, H-4-type mercury vapor lamp.

TABLE 1.—*Virus diseases exhibited by potato plants grown from tubers which showed varying degrees of intensity of fluorescence in ultraviolet light.*

Condition of Resulting Plants	Field Plants				Representative Progeny of Field Plants Grown in the Greenhouse			
	No Fluorescence	Low Fluorescence	Moderate Fluorescence	Intense Fluorescence	No Fluorescence	Low Fluorescence	Moderate Fluorescence	Intense Fluorescence
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
Healthy	30.7	7.9	3.4	0.0	0.0	0.0	0.0	0.0
Spindle tuber	6.6	9.9	8.6	7.5	26.3	12.5	4.3	34.0
Mosaic (all types)	30.8	43.5	28.1	18.7	23.7	51.8	63.0	26.5
Mosaic and spindle tuber combined	2.2	5.9	6.9	3.7	18.4	16.0	0.0	5.7
Leafroll	0.0	0.0	6.9	7.5	15.8	0.0	2.2	0.0
Haywire	19.8	21.8	31.0	37.4	2.6	0.0	4.3	1.9
Hairsprout	0.0	0.0	0.0	6.6	7.9	7.1	6.5	13.2
Missing	9.9	10.9	15.5	18.7	5.3	12.5	19.5	18.9
Total No. of Plants	91	101	116	107	38	56	46	53

It may be seen that, as the intensity of fluorescence increased there was a decrease in healthy plants in the field,—from 30.7 to 0.0 per cent. There was a corresponding increase in the amount of leafroll in the field. Haywire, hairsprout, and missing plants showed an increase in both the greenhouse and field. Haywire and hairsprout together may be considered to constitute the "haywire complex," since the second-year symptoms of haywire generally result in very weak plants or non-emergence. Spindle tuber and the various mosaics were distributed throughout the four classes, and although the mosaics showed a tendency to fall in the low and moderate classes, it was apparent that the intensity of fluorescence did not limit the distribution of either the mosaics or spindle tuber.

The fact that no healthy plants were obtained in the greenhouse trial is attributed to current-season spread of the viruses in the field and the greater accuracy of reading in the greenhouse. The appearance of such a high percentage of diseased plants from non-fluorescing tubers in the field study was understandable when it was later observed that small tubers from diseased plants frequently failed to fluoresce. It had been observed at planting time in the field that the non-fluorescing tubers had averaged approximately 1½ inches in diameter and were less than one-half the size of the tubers in the other three classified groups.

It appeared that the separation of tubers based solely on the intensity of fluorescence was not successful where spindle tuber and mosaic were concerned. In an attempt to determine the reason for this failure, 130 tubers were selected at random from a badly diseased lot and were read in ultraviolet light. These tubers were classified on the basis of location and color of fluorescence as well as the relative intensity of fluorescence. Tubers were placed in three classes: (1) Ring fluorescence—a yellow or white fluorescence in the vascular ring (in the absence of infection by ring-rot bacteria or tuber-invading fusaria); (2) diffuse fluorescence—a diffuse fluorescence throughout the cut surface of the tuber, generally blue or bluish white, with no distinct fluorescence of the vascular ring; (3) cortical fluorescence—a brilliant white color general throughout the cortex or white spots appearing in the cortex and other parenchymatous tissues. Following classification in ultraviolet light, the tubers were planted in the greenhouse. The distribution of diseases in the resulting plants is shown in the three columns on the left in table 2.

TABLE 2.—*Types of virus diseases and numbers of virus-infected plants grown from tubers classified on the basis of the color and location of the fluorescence shown in the tuber under ultraviolet light.*

Disease Reading in Greenhouse	Numbers of Plants Infected with Different Viruses Grown from Tubers Exhibiting Three Types of Fluorescence					
	Readings on 130 Trial Tubers			Reclassification of Notes[1]		
	Ring Fluorescence	Diffuse Fluorescence	Cortical Fluorescence	Ring Fluorescence	Diffuse Fluorescence	Cortical Fluorescence
	No. of Plants	No. of Plants	No. of Plants	No. of Plants	No. of Plants	No. of Plants
Spindle tuber	12	7	0	21	14	0
Mild mosaic	0	12	0	6	15	0
Crinkle mosaic	0	5	0	1	7	0
Rugose mosaic	0	6	10	0	6	17
Mild mosaic and spindle tuber combined	0	4	0	0	4	0
Crinkle mosaic and spindle tuber combined	3	0	1	11	1	3
Rugose mosaic and spindle tuber combined	4	7	3	14	7	8
Leafroll	45	0	0	46	0	0
Haywire	0	0	0	4	0	0
Hairsprout	6	0	0	15	0	0
Missing	3	2	0	10	4	0
Total No. of Plants	73	43	14	128	58	28

[1]These data are a total of all notes which could be applied to this system of classification. They include the 130 trial tubers (the three columns on the left) and 84 additional readings. The source of the latter is given in the text.

Is is apparent in table 2 that fluorescence of the vascular ring generally indicated leafroll, haywire complex, or spindle tuber. Further it was found that these diseases could be separated, since the vascular rings of tubers infected with the spindle tuber virus generally displayed a yellow fluorescence, whereas those of leafroll-or haywire-infected tubers showed a white fluorescence. When fluorescence was observed in the vascular ring, the only mosaic which appeared was that which was in combination with spindle tuber. Tubers showing a diffuse fluorescence produced, for the most part, mosaic-infected plants or combinations of mosaic and spindle tuber, although a few plants infected only with spindle tuber also appeared in this group. Thirteen out of 14 tubers displaying cortical fluorescence produced plants which showed the symptoms of rugose mosaic. The remaining plant could have been rugose mosaic also since all readings were made on plant symptoms alone.

Since the authors recognize the lack of sufficient numbers used, the three columns on the right in table 2 were prepared in an attempt to estimate the error in such a system bv including other data. These additional data were obtained largely from marginal notes which indicated the relative location of the fluorescence but were not originally intended for use in such a classification. In this portion of the table there is more overlapping between spindle tuber and the mosaics. The general relationship of type of fluorescence to the disease, however, remains the same.

Even though the data herein presented are based on a relatively small number of tubers and deal with only one variety of potatoes, the authors believe the method herein described to be applicable to foundation and tuber unit seed plots and with refinement may possibly be used in the laboratory for disease identification and to supplement tuber indexing.

Summary

Potatoes of the Bliss Triumph variety were segregated into classes on the basis of the intensity, color, and location of the fluorescence of the tuber when cut surfaces were exposed to ultraviolet light.

The symptoms of certain virus diseases and virus-disease complexes which subsequently appeared in the resultant plants indicated that such diseases had been identified in the tubers of the Bliss Triumph variety with reasonable accuracy on the basis of location and color as well as intensity of the fluorescence observed.

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WAR APPROVED SEED POTATOES IN 1944

R. R. Pailthorp

Standardization and Inspection Division, Fruit and Vegetable Branch, War Food Administration, Washington, D. C.

At a meeting of State officials in charge of certification of seed potatoes held at Chicago on Dec. 1, 1943, representatives of the War Approved Seed Potato Committee of the U. S. Department of Agriculture submitted for consideration and approval suggested requirements for War Approved Seed Potatoes for the 1944 growing season. Representatives of official Seed Certification Agencies from Alabama, Idaho, Maine, Michigan, Minnesota, Nebraska, New York, North Dakota, Oregon, South Dakota, Utah, Wisconsin and Wyoming attended the meeting. After careful consideration of the suggested requirements, a few changes were recommended by the State officials.

Subsequent to the Chicago meeting this matter has been cleared with the War Approved Seed Potato Committee of the United States Department of Agriculture and also with other people in the Federal service who are interested in the seed potato program. Following is a copy of the minimum requirements as adopted at the Chicago meeting with the exception of a change in the pitted scab requirements which allowed not more than 5 per cent of any degree of deep pitted scab at time of final pack inspection and an additional requirement that the variety name be marked on the tags. Our Committee does not feel that any degree of deep pitted scab should be scored against the 5 per cent tolerance, therefore in the enclosed requirements this defect is not scored against the 5 per cent tolerance unless it has damaged the appearance of the potatoes. It is customary to mark the variety name on tags for Certified Seed and we feel that this same requirement should apply to War Approved Seed Potatoes.

The Committee has announced that they will approve State specifications for War Approved Seed Potatoes filed with them if such specifications meet the following Minimum Requirements for War Approved Seed Potatoes in 1944 dated April 12, 1944. It is emphasized that these are minimum requirements and any State may file with the Committee for approval requirements which are stricter, especially as to field inspection and final pack inspection.

Assurance has been given by the Office of Price Administration that their policy with respect to pricing the 1944 crop of seed potatoes will be to allow the same differential above table stock prices which they adopted for the 1943 crop.

The Office of Price Administration defines War Approved Seed Potatoes as "Seed potatoes grown, inspected, approved and tagged or labeled as being of such class pursuant to the laws and regulations governing the Official Certifying Agency of the State where grown, provided that the standards therefore as established by each State have been filed with and approved by the United States Department of Agriculture as meeting minimum Federal requirement for such class."

The seed certification agencies in the several States interested in War Approved Seed Potatoes are urged to submit their respective standards for approval as soon as possible and the Committee has promised to act promptly.

Minimum Requirements For War Approved Seed Potatoes Produced in 1944

General Requirements

War Approved Seed Potatoes shall consist of potatoes which have been field-inspected and grown in compliance with the rules and regulations of the Certifying Agency of the various States for growing certified seed and so identified by the Certifying Agency. All fields for approval shall be planted with seed approved by the State Certification Agency and shall comply with rules and regulations of the Agency for the production of War Approved Seed, provided such rules and regulations meet the following requirements:

Field Inspection

At the time of any field inspection by the State Agency, in order to qualify for approval, the field shall not show more than the following percentages of diseased plants, plants affected by insect pests, and varietal mixtures:

	Per cent
Leaf Roll	5
Mosaic	5
Yellow Dwarf	2
Spindle Tuber	5
Other Virus	3
Other diseases such as:	

Witches' Broom)	
"Haywire")	
Giant Hill)	
Rosette)	5
Spinach Leaf)	
Curly Dwarf)	
Total above not over	7
Varietal Mixture	1
Purple Top Wilt	5

Late Blight (if present to extent that satisfactory inspection can not be made on other diseases)

Bacterial Ring Rot	¼
Potato Wart	0
Nematode (eelworm)	0

Final Pack Inspection

At the time of final pack inspection, War Approval Seed Potatoes shall consist of potatoes which have passed the field inspection requirements heretofore enumerated and such other rules and regulations as may be required by the State Certifying Agency and which shall at least meet the lowest grade requirements for certified seed in the State where grown, and shall show not more than the following amounts for potatoes having any one of the defects listed below:

	Per cent
Spindle Tuber (visible)	2
Soft Rot or Wet Breakdown (any degree)	1
Deep Pitted Scab (damage)*	5
Stem-end discoloration (serious damage)*	6
Late Blight (any degree)	2
Hairsprout (any degree)	5
Varietal Mixture	1
Ring Rot (any degree)	1/10
Nematode (eelworm)	0
Potato Wart	0

Size

The minimum and maximum sizes may be fixed by agreement between buyer and seller. In order to allow for variations incident to proper sizing, not more than 5 per cent, by weight, may be smaller

*Interpretation of damage and serious damage shall be in accordance with the U. S. Standards for Potatoes.

than the specified minimum size and not over 15 per cent may be larger than any specified maximum size.

Tags

The container must be marked or tagged "War Approved Seed Potatoes" and show name of the variety, the name and address of grower, or grower's number, crop year, and address of the State Certifying Agency. (Recommend the use of orange-colored tags with black printing.)

Inspection

All War Approved Seed sold or approved for sale shall meet the final pack inspection requirements and shall be inspected by a Federal or Federal-State inspector, or a qualified representative of the State Certifying Agency. If the potatoes do not meet final pack requirements the brands or tags shall be removed unless the potatoes are regraded and pass inspection.

PARENTAL IDENTITY IN VARIETAL SELECTION NAMES

WM. STUART

Takoma Park, Washington, D. C.

Dr. J. R. Livermore's comments (1) with respect to the writer's suggestions, in a previous issue of the American Potato Journal (2) regarding the desirability of preserving the parental identity of potato mutants, seems to warrant further discussion. His review of the origin and development of Toanco, or Toanco No. 4, and the Pioneer Rural serves to fix definitely their parental source. The suggestion to add the suffix "Rural" to Toanco listing it as the Toanco Rural simply serves to identify it with the Rural and is less cumbersome than Toan's Rural New Yorker No. 2, Toan's selection as cited by the writer. Personally, I would like to see the Potato Nomenclature Committee adopt such a plan in their official recognition of future similar mutants.

It is interesting to note that both of the above selections—Toan's Rural and Pioneer Rural—were white-skin mutations of the Russet Rural, which variety was, in turn, a russet-skin mutation of the old Rural New Yorker No. 2. In other words, these two mutants were reversions to the original parental type. Such reversions are not at all uncommon, particularly in some varieties with respect to skin color as in the Peerless Triumph and Early Ohio.

The only satisfactory method of determining the actual superiority of a mutant compared with that of the parent plant is by a careful study of their performance when grown side by side in a number of localities.

In all instances such comparative tests should be made only in regions in which the parental variety is known to be adapted.

The application of distinctive names to selections from sexually propagated plants is not comparable to those from asexually-propagated ones, in that in the former there may be an entirely different combination of unit characters rather than a mutation of a single character as in the latter case.

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2. Stuart, Wm.—1944. Past accomplishments and future objectives of the potato nomenclature committee of the Potato Association of America. Amer. Potato Jour. 20: 241-247.

SECTIONAL NOTES

ALABAMA

The year 1944 will go down in history as well as in the memory of potato growers of the state as one of the most unusual years on record. Mild weather and excellent soil conditions permitted rapid and efficient planting of the crop. The seed pieces germinated promptly, and the crop started off under most favorable conditions. One light frost was passed with minor damage. Rains began in March and continued with very little break for about five weeks. On the level fields of Baldwin County, water stood in furrows for weeks. Estimates of reduced yields as a result of excessive rain in early April were placed at about 20 to 30 per cent; in late April, estimates of reduced yields ranged from 40 to 50 per cent. Late blight so uncommon in the South Alabama section began to appear first in the Bon Secour area, then later in the Robertsdale-Foley area. Doubt was entertained at one time that any potatoes would be shipped. The weather cleared the last week of April and the first week of May. Cars began to roll the last of April. While doubt was entertained about the shipping quality of the potatoes, reports on cars arriving at the market indicate a much better condition of the potatoes than had been expected. The present estimate of loadings range from 2,500 to 3,000 cars. At an earlier date 7,000 cars were expected. (May 9)—L. M. Ware.

CALIFORNIA

At this date (May 3), the potato growers of Kern County have shipped a total of 513 cars of potatoes from this year's early crop. Last year at the same date, 977 cars had been shipped. In 1942 on the same

date, a total of 1,428 cars were shipped. We have planted approximately 50,000 acres as compared with approximately 36,000 acres in 1943. This refers only to that acreage planted in the floor of the valley and does not include any of those planted in the mountains.

The market today is approximately $3.75 per hundred on U. S. No. 1 size A, and $3.50 for U. S. No. 1.

The fields that are being harvested at this time are largely those that had a severe setback caused by frost. In making a survey of some of the areas where frost damages were not so severe, the plants were showing satisfactory growth with an average set of tubers. Shipments will be heavy within two weeks. Peak shipments will occur in late May and early June. Our labor supply at this date is adequate. We cannot predict what the labor supplies will be when our peak shipping period arrives. If this labor is available, we will probably employ more than 7,000 people during our peak shipments. (May 3)—M. A. LINDSAY.

COLORADO

The Colorado potato crop has appeared cleaned up at different times during the season, but shipments are still holding at approximately ten cars per day. The total car lot shipments this year do not equal the car lot shipments a year ago, despite a million bushel increase in the government estimate for the state and a 6 per cent reduction in movement by truck. We hope that the government estimate has not been so far off in other states. There has been no dehydration of low grade potatoes in Colorado, and very few government purchases to support the market. In fact, Triumphs and McClures brought ceiling prices practically throughout the season. A vigorous educational campaign is again being conducted this spring, pointing out to growers that despite the excellent yields being obtained by some individual growers, the state growers, as a whole, ship only 90 sacks of potatoes for each acre of potatoes planted. The goal is being set for the shipping of at least 150 sacks for each acre of potatoes planted in the state.

The seed certification service has greatly expanded the indexing program, as this is practically the only means of eliminating mosaic, particularly in the warmer regions of the state. Special emphasis is being placed on Triumphs and White Rose. The Red McClure seed stock is now about as good as it can be made, as special tuber lines have been increased to the place where they are available to growers in general. The future of ring rot is rather uncertain, since it was thought to be well under control, but more was found during inspection last year than for two or three years previous to that date. Personnel for

inspection for the coming season is a serious problem, and it will be very difficult to handle the anticipated increase in certified acreage and to handle any acreage of war approved seed comparable to that of last year. The war approved deal will probably resolve itself into a second or lower grade of certified seed, and will probably consist mostly of stock just above the tolerance for certification. All of the certified seed in Colorado cleaned up early at practically ceiling prices, and there was a great demand for war approved seed, but probably only because there was not enough certified seed to go around.

The cold weather and steady precipitation throughout the spring months has held up farm work until the past few days. Potatoes which are normally planted early in April are just being planted at this time,—two weeks to a month later than usual. There will probably be a decrease in the July movement from the state, but August and September may perhaps be a little heavier than normal. Some increase in commercial acreage now seems probable, since some of the crops normally planted at an earlier date, particularly small grains, will be replaced by potatoes. Earlier in the season the growers signified an intention to decrease the acreage somewhat below that of last year, but it does not now seem probable that this will materialize. (May 13)—C. H. METZGER.

IDAHO

Present conditions still indicate that Idaho will have considerably less acreage than last year. The demand for certified seed has been good, but growers who are holding "one-year-out" seed, report that it is moving slowly. Some of the decrease in acreage is indicated to be from growers who planted small acreages last year, and in districts where potatoes were not grown previously in 1943. Idaho is still shipping some old crop potatoes at ceiling prices, but the deal is pretty well over for this year. The demand has been good throughout the season, and there has never been a time when it was necessary for the government to support the price in Idaho. The program announced through A. A. A. of payments for making silage of No. 1's and 2's will receive little attention in this state.

A War Approved Seed program for Idaho will be carried out in 1943. Regulations established by the Idaho Crop Improvement Association will be much stricter than the minimum requirements allowed by the War Foods Administration. The program has been established mainly because of O. P. A. price regulations.

Only a small acreage (the early crop) has been planted as yet, and

it is too early to report any condition of this crop. The main, or late crop, will be planted between the 15th of May and the 10th of June, with present conditions indicating a little later average date than last year. Storms during April improved the water situation to some extent by delaying the first irrigation. (May 3)—EUGENE W. WHITMAN.

INDIANA

For the past three or four weeks the conditions in Indiana have been rather damp. There will be some delay in planting potatoes, although there isn't any hurry. Most of our potato dealers have a good supply of certified seed on hand, and due to some unique method of salesmanship these dealers have been able to pass on to some of the smaller growers and gardeners some of the poor War Approved seed. (May 3)—W. B. WARD.

NEBRASKA

The Government diversion program that was launched for the purpose of disposing of 2,000 carloads of low grade potatoes in this area has been terminated. An excess of the original quantity was shipped. Potatoes of U. S. No. 2 quality were taken on this program, loaded in gondola cars, and shipped to sugar factories in this territory. The potatoes were sliced and dehydrated, and will eventually be utilized in alcohol production, or as a component of stock feed. The evidence on hand at this time indicates that the final product has a food value equivalent to barley, which is about 80 per cent that of corn. Feeding experiments with lambs have been initiated, and the preliminary results seem to be satisfactory.

There is still a small table stock movement from the territory, with a very active demand for both No. 1 and No. 2 quality. Sprouting of potatoes is making the source very limited. Very little additional local seed demand exists, though this market usually carries on in some manner until after the first of June, when planting is begun. So much for the old potato market.

Planting of the early crop in the Kearney-Gibbon areas of central Nebraska has been materially delayed because of excessive rains. Western Nebraska areas have had a good rainfall, which has somewhat delayed farming operations, but not nearly to the extent that exists from central Nebraska eastward. Some growers report that their planting operations have been delayed from two to three weeks later than their usual planting time.

As indicated above, good moisture conditions exist in western Ne-

braska at this writing. If special methods for conservation of moisture are followed, this will result in good planting conditions.

An occasional field of early potatoes has been planted in western Nebraska, but an intensive campaign launched by the Potato Improvement Association is discouraging early planting in this western area, as this has been shown to be the source of heavy infestations of psyllid and flea beetle for the later planted crop.

The Nebraska Potato Improvement Association, with the backing of dealers, growers, railroads, college specialists and extension service throughout the territory has launched a comprehensive program for the improvement of all potatoes in Nebraska. A full time field man, in the person of Phillip Hoff, formerly with the Consumers Cooperative Cannery, of Scottsbluff, has been put in charge of the program. The acreage of potatoes to be planted in Nebraska probably will shrink somewhat from last year, with the possible exception of certified potatoes. The certified crop, from early indications, appears to be headed for a slight increase. (May 9)—MARX KOEHNKE.

NEW JERSEY

Practically all of the commercial potato acreage is now planted. Some of the earlier-planted potatoes are now above ground, and cultivation is well under way. A few growers have reported poor stands caused by seed piece decay, and others have had to replant a portion of their crop. However, the latter condition is not general.

Approximately, 71,000 acres have been planted in potatoes again this year, which is about 1,000 acres less than were our intentions to plant on the 1st of March.

Some growers are top-dressing their potatoes with nitrates and potash because of the leaching due to the rather frequent and heavy rainfalls we have experienced. (May 12)—J. C. CAMPBELL.

NEW YORK

Potato planting conditions are much more favorable now than at this time a year ago. A recent report from N. A. Talmage of Riverhead, Long Island, indicates that the Suffolk County acreage was planted as early as normal and that the plants are already emerging. The first cultivation will begin the week of the 15th of May. He reports that the germination was at least average, although a few fields had to replanted because of seed piece decay. This problem of Fusarium rot of seed pieces has been increasing on the Island in recent years. On the west end of Long Island, wet weather delayed planting much beyond the

normal season. Some of the larger growers did not finish planting until the 8th of May.

In Upstate New York, the first two weeks of May were especially favorable for plowing and seed bed preparation. There is every indication that planting will proceed during the normal period, from the 20th of May to the 15th of June. This will be almost a month earlier than a year ago. Although the published intentions to plant in New York indicated a two per cent decrease compared with last year, and a five per cent decrease under the ten-year average, we believe that the acreage planted will be very close to that of last year. The supply of good seed is not so short as was reported earlier this spring. It is the feeling on the Island that there may be some increase in acreage compared with that of last year. Many acres in central Suffolk County, Long Island, have been planted to potatoes this year for the first time. Although they will not produce the average yield for Long Island, they will contribute to the total production. Potatoes and cauliflower are competing crops on Long Island. Most of the soils suited for cauliflower are already in use. Any increase in production between these two crops is, therefore, more likely to be of potatoes. Steuben County, the largest potato county upstate, expects to begin planting at least a week earlier than usual,—in this case about the 20th of May. (May 15)—E. V. HARDENBURG.

OHIO

Wet weather during the latter part of March and the first of April was responsible for three to four weeks delay in planting the early crop of potatoes. Very few potatoes had been planted before the last week of April. The weather has been excellent for planting during the past week and most of the early crop is at last in the ground.

There is an abundance of certified seed still for sale. Practically all the stores have seed on hand. They evidently were planning on heavy sales to Victory gardeners. Either the Victory gardeners are discouraged because of their poor potato crop last year, or the wet weather has been responsible for delayed buying. There will be a considerable quantity of certified seed sold as table stock.

The commercial planting in Ohio will be about the same as in 1943, but the total acreage will be reduced from four to five per cent. This reduction will be from small growers and Victory gardeners.

Ohio produced 400 bushels of certified Erie potatoes and 22,000 of the War Approved Seed. Since most of this War Approved Seed was expected to be sold to small growers and Victory gardeners, there is still considerable quantity available.

The old potato market has been slow and there are still some potatoes to be sold. During the last few days the markets have strengthened, because of the situation in the South. (May 8)—E. B. TUSSING.

OREGON

Potato acreage in Oregon will be reduced rather drastically from the 53,000 acres reported last year. The reason for the reduction is largely poor quality because of flea beetle injury in western Oregon. The principal shipping districts, Klamath and Deschutes, will have little, if any, reduction. Southeastern Oregon (Malheur County) last year grew about 10,000 acres mainly for shipping in August and the acreage in that county will be about cut in half. There is a local sugar beet factory and the acreage thus released will largely go into sugar beets.

Seed demand for Netted Gems was brisk at the end of the season and most of the certified Gems cleaned up at ceiling prices. Seed demand for Burbanks was poor because of reduced Burbank acreage in western Oregon and lack of call from California. The seed demand for White Rose was so great that all of the seed in this state was sold long before harvest-time. Much of it was sold before it was planted last spring.

War approved seed has not met with too much favor in this state except, of course, in the case of White Rose where anything that could legitimately be called a White Rose potato sold at the ceiling price. It is likely that not many growers will deliberately plant potatoes for war approved seed and probably the big bulk of war approved seed in 1944 will be from fields that could not quite pass as certified seed. (May 15)—E. R. JACKMAN.

The shipment of certified seed potatoes is about completed for 1944. Planting is now under way, with an increased demand for certified seed. The indications of acreage for this area are about the same as 1943,—consisting of 25,000 acres. Our season is slightly early. The biggest problems we are facing, are shortage of labor and machinery. Lack of labor might yet decrease the total acreage planted. (May 10)—C. A. HENDERSON.

VIRGINIA

Potato planting began on the Eastern Shore of Virginia at the normal time. Plantings did not continue long in regular order, as repeated heavy rains prevented regular planting on the Eastern Shore of Virginia and caused great damage in earlier plantings along the Seaboard and Gulf States. As a result the end of the planting season in the

Shore area was nearly 30 days late, with a large part of the planting being made at least three weeks after normal time.

The unseasonable weather not only delayed planting, but it also helped reduce acreage below that which had been anticipated. There is no way at the moment of determining the acreage reduction from unseasonable weather and other causes. The general impression is, that about 90 per cent of the intended acreage was planted. There is some loss of planted acreage in low spots, but the loss as yet, cannot be determined. In addition some plants are not normal in appearance. The extent of this and what it may mean is yet to be determined.

White potato production prospects have therefore been decreased by late planting and by a decrease in acreage. However, the yields on this late-planted acreage will depend greatly upon the growth of the plants and the character of the season. Even with good growing conditions one would not expect more than 80 per cent of a normal yield.

Perhaps the fear of unprofitable ceilings reduced the acreage somewhat. However, the fact that ceilings have not been invoked as yet on the early crops, due, perhaps, to the abnormal growth conditions in early and intermediate areas, has tended to promote late planting.

Labor shortage and the inability to secure grading machines are also presenting a problem for which no solution is in sight.

The light prospective yields generally prevailing in the early and intermediate potato areas will, undoubtedly, raise the unit cost of production above the ceiling prices that were in prospect, but which as yet have not been invoked. The same production conditions seem to prevail generally with other perishable fruits and vegetables in southern areas. This condition serves to emphasize the need of machinery within the Office of Price Administration which shall have authority to adjust ceiling prices immediately, where price orders have been issued, if yields are below normal, in order to prevent hardship to the producers. (May 2)—G. S. Ralston.


TREATING SEEDS
SAVES
CROPS AND
DOLLARS
Control
SCAB and
RHIZOCTONIA
by using
WOOD RIDGE AGRICULTURAL
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CORROSIVE SUBLIMATE
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RELATION OF HEAT AND DESICCATION TO BACTERIAL SOFT ROT OF POTATOES

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and

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Any one who deals with the handling of potatoes on the market is familiar with the soft, foul-smelling rot that damages many shipments and frequently makes extensive and expensive sorting necessary before the lot can be sold. The rot is most often found in the second-early and immediate[3] crops, that for the most part are shipped during May, June, July and August. It is by no means uncommon, however, in late-crop potatoes that reach the market in September or even as late as October. The occurrence of the rot is sometimes ascribed to faulty transit conditions, sometimes to injury by hot sun in the field, and sometimes to rough handling during digging, grading and loading. It is often referred to as "sunscald."

No definite figures are available that show the total loss from this rot in potato shipments for the country as a whole. However, no one who has been on potato team-tracks in the large terminal markets and has seen three or four or a dozen cars, each with a large pile of

[1]Senior Physiologist

[2]Associate Physiologist.

[3]These terms are used here in the sense in which they are used in "Agricultural Statistics," issued annually by the U. S. Department of Agriculture.

decayed potatoes outside the open door and men at work inside reconditioning the load, needs to be told that the rot can be a serious problem. Instances are known where 100 to 200 or even more than 300 bags of a carload had to be reconditioned, the total wastage sometimes varying from 10,000 to 25,000 pounds or more per car. The damage is undoubtedly not identified in the minds of receivers and handlers as one specific disease, and it is entirely possible that when the rot in a shipment is heavy, more than one decay organism is concerned. There is good evidence, however, that bacterial soft rot (sunscald) in early and intermediate crop potatoes shipped directly from the field is due chiefly to one condition or set of conditions. It is the primary purpose of this paper to discuss the relation of the rot to these conditions.

Before entering on this discussion it is important to mention another cause of damage to potato shipments. This is the unsightly browning or blackening that develops on skinned places exposed to dry air and the stickiness frequently seen on such discolored places by the time the potatoes arrive on the market. The injury is of importance mainly as a blemish because, unlike soft rot, it does not cause total destruction of potatoes. Growers are much less likely to see either the rot or the browning than are shippers or receivers, because neither condition develops to any marked extent until a day or two after the potatoes have been dug and shipped.

Effect of Heat on Potatoes

The term "sunscald" mentioned above expresses the rather common belief among growers, shippers and receivers that bacterial soft rot of potatoes is caused by exposure to the sun in warm or hot weather. Investigations on the subject conducted by Peacock, Wright, and Whiteman, and by various other investigators in the Bureau of Plant Industry, Soils, and Agricultural Engineering,[2, 3] have shown that the heat of the sun is a factor that must be considered in any attempt to determine the cause of "sunscald."

In the investigations discussed here an attempt was made to determine more definitely than had been done previously, how freshly dug potatoes are affected by heat. Since the heat energy (or radiant heat) in sunlight is largely in the infra-red rays, lamps were used that were built especially to emit these rays. Tubers were exposed to the rays of

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[1]Evans, L. H.; Lutz, J. M.; Pentzer, W. T.; Barger, W. R.; Wright, R. C.; and Schomer, H. A. Part of this work has been reported in mimeographed circulars furnished to growers, shippers, receivers and railroads who cooperated in the investigations.

a battery of two infra-red lamps for various lengths of time, the lamp assembly being set so that the bottoms of the lamps were at various heights from about 2½ to 1½ feet above the surface of the potatoes.[5] Under such conditions the temperature of the potato flesh about 1/16 of an inch below the skin (as measured by small thermocouples) rose 30 to 60 degrees F. in two to three hours, the amount of rise depending on the height of the lamps above the potatoes and the length of the exposure. In every test with freshly dug potatoes, in which the tissue temperature (see the discussion and figures that follow) rose to 135° to 140° F. or higher, the skin and underlying flesh directly beneath the lamps darkened to a purplish black within 10 to 15 minutes after the high temperature was reached, and juice began oozing from lenticels in the darkened area (Figure 1). These are symptoms that resemble very

[5]From data furnished by the manufacturer of the lamps used, it is estimated that when set at these heights they emitted heat energy amounting to 0.40 to 1.00 watts per square inch at the potato surface. For sunlight on an average clear summer day with the sun at the zenith, the heat energy reaching the earth's surface probably amounts to about 0.70 watts per square inch, or nearly a third less than the highest figure estimated for the lamps.

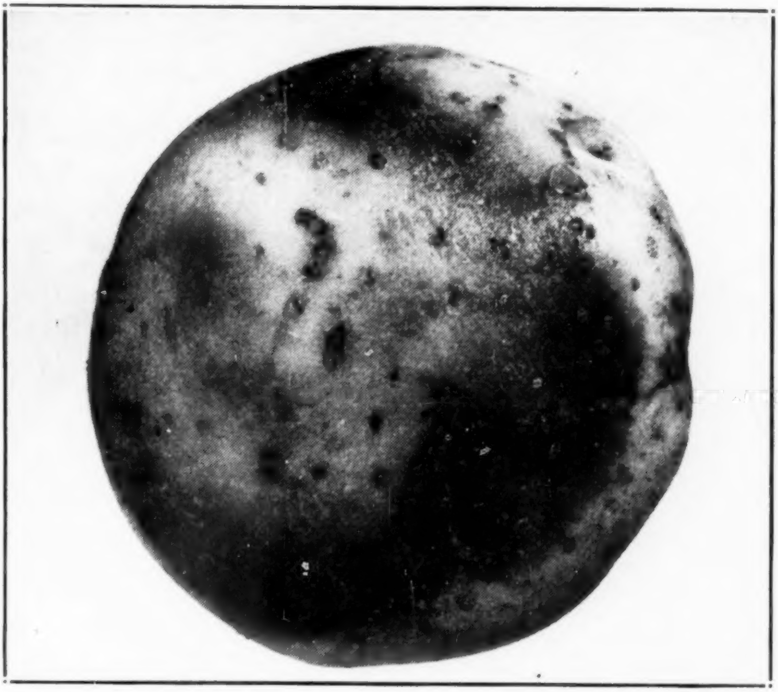

FIG. 1—A. EXTERNAL VIEW

closely those seen many times in the field on potatoes harvested in warm or very hot weather. The experimental work has even reproduced the bleaching or destruction of skin color seen frequently in the field on red-skinned varieties. In a few instances injury was noted in the experimental lots at 125° to 127° F.

At the time potatoes under the lamps had reached the maximum temperatures mentioned above, the tissue temperature was 1 to 3 degrees F. lower a sixteenth of an inch below the surface than it was at the surface, and the latter temperature was 4 to 5 degrees F. higher than the air temperature a sixteenth of an inch above the surface. At the same time, a thermocouple 1/4 inch below the tuber surface showed temperatures 2 to 8 degrees F. lower than those found at a depth of a sixteenth of an inch.

When some of the thermocouples were laid on the surface of potatoes and others were suspended an inch above the surface and parallel to it, the differences in temperature were very large. Figure 2, presenting the results of one experiment, shows that within half an

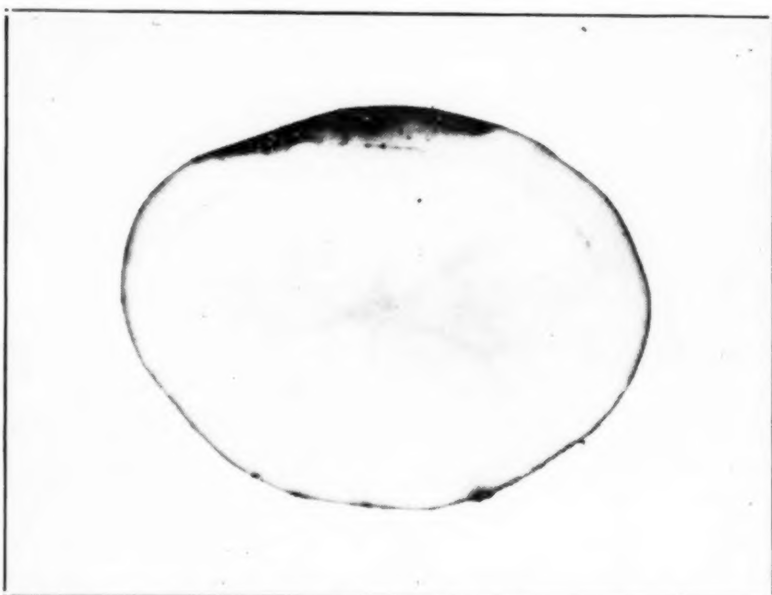

FIG. 1.—B. CROSS SECTION

FIGURE 1. Katahdin potato exposed to rays from infra-red lamps for two hours and a half, showing the darkening that developed 10 minutes after the tissue temperature reached about 135° F. A—External view. B—Cross-section Oozing at lenticels occurred at several places over the exposed surface. October, 1942.

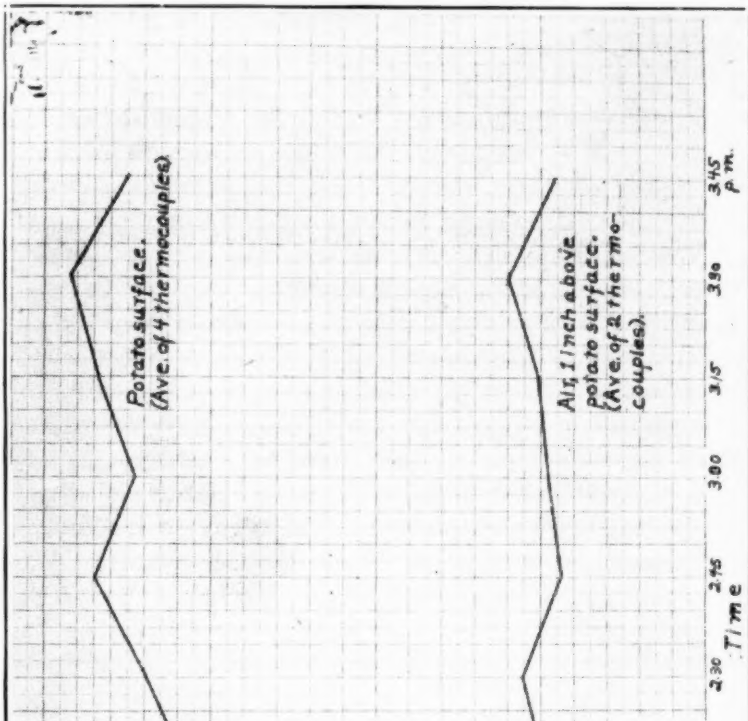

FIGURE 2. Difference between tissue temperature (at potato surface) and air temperature 1 inch above the surface, when a Russet Burbank potato was exposed to rays from two infra-red lamps for two hours and 35 minutes. Average air temperature during the experiment, 101.5° F. October, 1942.

hour after the experiment was started, the surface of the potatoes was about 16 degrees F. warmer than the air an inch above it; and after two hours and 20 minutes the potato surface was slightly more than 32 degrees F. warmer. In another test the difference when the surface temperature reached the maximum (about 135° F.) was 42 degrees F.

It is evident that there was an accumulation of heat in the potatoes after a prolonged exposure to the infra-red rays, and that the resultant flesh temperature was far above that of the surrounding air. In other words, heat injury can be produced in potatoes when air temperatures are not excessively high. This has also been shown by observations made during experimental work in the field, notably at Arlington Farm, Virginia, in 1938 and in Nebraska in 1942[7]. However, the possibility that prolonged exposure of potatoes to the sun on a day that is only moderately warm may cause heat injury, is not so clearly understood as it should be by growers and shippers. The failure to realize this possibility may result in unexpectedly serious loss during the marketing of a crop. Shortage of help, under wartime conditions, may delay the picking up of potatoes after they have been dug and so increase the danger of heat injury, but the delay should always be made as short as possible.

Relation between Maturity of Potatoes and Their Susceptibility to Heat Injury

Dakota Red potatoes were harvested from the same field from September 28 to October 27, 1942, at weekly intervals for five weeks, and therefore at different stages of maturity. Different lots of each of these harvestings were exposed to infra-red lamps in such a manner and for such lengths of time that they reached a maximum temperature of approximately 105,° 115,° 125,° or 135° to 140° F. and remained at or near that temperature for at least an hour. All potatoes so exposed showed the typical symptoms of heat injury, provided the tissue temperature eventually rose to 135° to 140° F. Discoloration and oozing at lenticels were observed in a few potatoes that reached 115° to 125° F. The first digging was no more susceptible than the last. However, freshly dug potatoes of any maturity were much more susceptible to the injury than those that had been held in dry air in the laboratory for two or three days.

[6]See footnote 4, p. 150.

These facts had no bearing on the harvesting of this particular crop of potatoes because there were wide differences between air temperatures in the field at the time of the different diggings, the weather being much cooler at the end of October than during the last week of September. The results are important as indicating what can be expected when field conditions (exposure to radiant heat from the sun) approximate those to which the test lots were subjected in the laboratory, by exposure to radiant heat from infra-red lamps.

In several experiments, skinned and unskinned potatoes were placed under the infra-red lamps, with thermocouples (1) lying on the surface; (2) thrust under the surface and parallel to it at a depth of about 1/16 inch; and (3) suspended parallel to the surface about 1/16 inch above it. The skinned places averaged roughly one square inch in area. In all of these experiments, air and tissue temperatures at the skinned places were lower, sometimes much lower, than those found where the skin was intact. In one extreme instance, the differences between skinned and unskinned areas at the end of the experiment were 15.0 degrees F. at the surface, 18.6 degrees just under the surface, and 21.7 degrees a sixteenth of an inch above it. The most obvious explanation of these differences is that where the skin had been removed, some of the heat was absorbed by the evaporation of moisture from the freshly exposed surface. This evaporation is so rapid that it can cause noticeable sinking of the flesh in 15 minutes. When it continues for two to three hours or more, it causes the marked sinking or pitting mentioned previously.

Relation of Heat Injury to Bacterial Soft Rot

Wiant, Schomer, and McColloch[7] found in 1938 and again in 1939 that under ordinary conditions it was practically impossible to infect sound potatoes with bacterial soft rot. However, if the potatoes were heated to a temperature of 115° to 125° F. for an hour or more, and then held at 90°, infection was relatively easy. In order to obtain further information on this point, all of the potatoes exposed to infra-red lamps in these later tests were placed in moist chambers at the end of the experiment, and held at 90° F. for two days. In all tests with the exception of three, the potatoes were washed and dried, but not sterilized, before being placed under the lamps. All of the unsterilized tubers that reached 135° to 140° F. and showed oozing at lenticels, or flesh

[7]Unreported work done at Arlington Farm, Va., 1938, 1939.

darkening, or both, by the end of the test, and a few that reached only 115° to 125° and showed only the flesh darkening, had the usual symptoms af bacterial soft rot—puffy condition of the flesh and bubbles of gas as affected spots, and foul odor—after 24 hours at 90°.

These symptoms have long been considered characteristic of "sunscald." They may also occur at cuts and bruises if temperature and humidity are favorable. That they do not necessarily develop when potatoes are injured by heat was shown by the following experiment: Potatoes were washed with soap and water, then dipped in 95 per cent alcohol and finally submerged in a 1 to 1000 solution of mercuric chloride where they remained for an hour. At the end of that time they were removed from the solution with sterilized laboratory tongs, placed under the infra-red lamps (on towels soaked with mercuric chloride solution) and kept there until the tissue temperature just beneath the epidermis had reached 135° F. After approximately 10 minutes at that temperature they showed the oozing at the lenticels and the darkening of flesh and skin already described. They were then removed with sterilized tongs, placed in a sterilized moist chamber on paper towels wet with mercuric chloride and held at 90° F. for a week. At no time during that period did they show any of the symptoms of bacterial soft rot or any other decay. All potatoes remained unchanged in appearance and there was no bad odor. At the end of the week they were as firm as when placed in the moist chamber. Similar results were obtained in[2] other experiments that replicated the first.

At the conclusion of one of these tests, that is, after the week of incubation at 90° F., the potatoes were washed thoroughly, then rubbed with unwashed, unsterilized potatoes and again held at 90° At the end of three days they were in an advanced stage of bacterial soft rot, despite the fact that they had previously remained for a week at 90° (after the heat treatment) without showing any sign of the rot. It was thus proved that heat injury and bacterial soft rot are two different phenomena and that the rot follows the injury only if bacteria are present and conditions are favorable for their growth. Under commercial conditions there is no question of the presence of the bacteria that cause the soft rot, because they are common soil organisms and potatoes are almost certain to be thoroughly contaminated with them. It is possible that the soft rot found in commercial potato shipments is caused by more than one kind of bacterium or by more than one strain of the bacterial soft rot organisms *Erwinia carotovora*, and *E. aroideae*. No information has been obtained

in these investigations that would be of much help in clearing up this situation.

In view of the foregoing statements it is evident that the development or non-development of bacterial soft rot on potatoes in transit is largely a matter of transit temperatures, provided of course that, prior to shipment, the potatoes have been subjected to the conditions already discussed that predispose them to the rot.

Potato shipments originating in Florida and others of the more southerly producing sections are harvested in weather that is cool or at most only moderately warm, and as they move northward they encounter cooler and cooler weather. Potato temperatures in such shipments while in transit are probably below 70° F. during most of the trip, and this, as has been shown by large-scale storage tests[8] is low enough to hold bacterial soft rot in check almost completely. As a consequence such shipments are rarely damaged by soft rot. On the other hand, shipments from Mississippi, the Carolinas, the Eastern Shore, the Kaw Valley, Central Nebraska, and other second-early and intermediate crop sections are harvested in warm to hot weather and unless refrigerated in transit are likely to be subject to high temperatures (possibly 80° to 90° F. or higher) on the way to market. Consequently, if the potatoes have not been picked up, hauled from the field, and placed in the shade promptly after digging, they are likely to have suffered heat injury that makes bacterial soft rot in transit (in varying degrees, of course) almost a foregone conclusion. Under wartime conditions, shortage of labor or sudden local scarcity of containers is likely to delay the removal of a crop from the field and so to aggravate the effect of all the factors that favor decay in transit. The heavy losses from rot that occurred in the spring of 1943 in shipments of second-early crop potatoes from some of the southern states were at that time ascribed largely to lack of ice for refrigeration in transit. There is reason to believe, however, that much of the loss was due to unavoidable exposure of potatoes to the heat of the sun when help could not be obtained to get them picked up and hauled out of the field promptly after they were dug.

Potato growers and shippers will do well to recognize the dangers they face this coming season, with the labor shortage probably even more acute than in 1943, and take such measures as they can to avoid them. If shortage of ice makes it difficult to furnish refrigeration in transit, potatoes that have been promptly handled are less likely to

[8]See footnote 6, p. 154.

develop transit decay than those that have lain in the sun for several hours after being harvested.

Browning of Skinned Potatoes

In an earlier investigation by Rose and Fisher it was found that skinned areas on potatoes became browned when the potatoes were exposed to rapidly moving dry air, but that little or no browning occurred when the air was very moist. It was also found, (1) that skinned potatoes held in moving moist air for nine hours or less and then in dry still air at room temperature showed marked browning and considerable shriveling after 24 hours; (2) that when skinned potatoes were "blown" with moist air for 12 hours or longer and then held in dry air, they remained free from browning and did not shrivel. It was suggested that exposure to moist air for 12 hours or more allowed suberization of the skinned areas to take place and that this process protected those areas from browning and also from loss of moisture.

Potatoes Held in Moist or Dry Air Indoors

In an attempt to determine the minimum time in which suberization of skinned surfaces of potatoes can occur under optimum conditions, a microscopic study was made of material from skinned potatoes that had been "blown" with moist air for 3, 5, 7, 9, 12, 15, 18, 21, and 24 hours. Pieces of tissue 8 to 10 mm. long and approximately 4 x 4 mm. in cross-section cut from the skinned areas were killed and fixed in a chrom-acetic solution (1 g. chromic acid, 1 ml. glacial acetic acid, and 100 ml. water), embedded in 55° paraffin, and sectioned 20 u thick. The sections were stained with ammoniacal gentian-violet as follows:

Two solutions were used, one consisting of 70 ml. of a 1 per cent gentian-violet solution in 80 per cent alcohol, the other of 28 per cent aqua ammonia. These were kept in separate bottles, and mixed only when placed on the slide, usually in the proportion of 7 drops of the stain to 3 drops of ammonia. The typical blue color was obtained in naturally occurring suberized periderm of unskinned areas by staining only 3 to 5 minutes (in contrast with the "several hours or overnight" recommended by Artschwager) and then destaining with 8 per cent hydrochloric acid followed by 95 per cent alcohol. When the blue color was produced by this method in cell walls of tissue from skinned areas, it was accepted as evidence of suberization. Staining for more than 5 minutes did not accentuate the blue color. The only precaution found necessary was not to use a gentian-violet solution that was more than about a week old.

Study of stained sections made from the embedded material gave the following results: Skinned areas on potatoes blown with moist air showed slight but definite suberization of the outer layer of cells if the blowing had continued for at least 12 hours. The shortest time previously reported by Artschwager (1) in which suberization can occur was one day.

Skinned areas blown in dry air for only half an hour developed the false cicatrice of brown or black, dead cells described by Werner (5) but did not show suberization until after 16 to 24 hours, mostly 18 to 24 hours. It thus seems evident that the reason why skinned potatoes blown for 12 hours in moist air do not shrivel when afterward held in dry air is that they have begun to suberize, and so are protected against water loss. It is not clear, however, why skinned potatoes in either still or moving moist air brown very little if at all, whereas those in dry air, especially if the air is moving over them rapidly, show marked browning in half an hour.

Potatoes Exposed to Various Conditions in the Field

The browning of skinned areas on potatoes, in the field or on the way to market, is well known to potato growers, shippers and receivers, and has been the subject of numerous investigations by workers in the Bureau of Plant Industry, Soils, and Agricultural Engineering, United States Department of Agriculture during the period from 1938 to 1943.

Skinning and subsequent browning cause damage to potatoes in two ways. In the first place, the removal of the skin permits water loss and may result in noticeable shriveling either during harvest or while the potatoes are on their way to market. Small skinned areas often become much sunken, forming unsightly pits that are sometimes ascribed to bruising. In the second place the browning, although usually only slight at shipping point, may become much worse in transit. That is, the color may darken to almost black and the skinned spots may become sticky with bacterial and mold growth if the potatoes are in tight containers or in a car, where the humidity in transit is high. Browning and stickiness count heavily against the sale value of potatoes on the market. They probably are a more frequent cause of loss to growers and shippers than bacterial soft rot because, unlike the rot, they can and do develop at moderate temperatures (60° to 70° F., or even lower). Bacterial soft rot develops very little if at all unless the potato temperature, immediately after harvest and in transit, is well above 70°. So far as the

writers have observed, the sticky condition that sometimes develops on browned skinned spots does not go over into the soft, puffy, foul-smelling rot (bacterial soft rot) discussed earlier in this paper.

All of the eleven commercial varieties that have been observed are susceptible to browning of skinned areas, some much more so than others. The variety Sebago is the least susceptible of all and, apparently for that reason, is replacing Katahdin (which browns easily) in some of the large producing regions of the South.

For purposes of comparison with the material described in the previous section, a second series was prepared from skinned and from cut potatoes dug at 10:00 a. m. and exposed in sun and shade in the field for 0, 2, 4, and 6 hours at Arlington Farm, Virginia. The air temperature and relative humidity in Washington, D. C. (just across the Potomac River), during the exposure period, as reported by the United States Weather Bureau, were as follows:

	10 a.m.	11 a.m.	12 noon	1 p.m.	2 p.m.	3 p.m.	4 p.m.
Temp. Deg. F.	83°	84°	86°	87°	88°	89°	90°
Rel. humidity, per cent	57	55	52	51	49	47	46

Within about 15 minutes after being picked up the potatoes were placed in a storage room having a temperature of 70° F. and a relative humidity of about 85 per cent, where they were held until noon of the following day. Pieces of tissue were cut every two hours for 26 hours after the potatoes were placed at 70°, from the skinned or cut surfaces, and were killed, embedded, and sectioned as described above. Examination of stained sections of this material showed that suberization occurred within 16 to 25 hours after the potatoes were skinned or cut. There were no consistent differences in rate of suberization between cut surfaces and skinned surfaces, and there was no consistent relation between suberization and the length of time the potatoes were exposed, or between potatoes exposed in the sun and those exposed in the shade.

It was observed, however, that in material from potatoes exposed in the shade, suberization occurred in the outermost cells of both skinned and cut surfaces. When the potatoes were exposed in the sun the outermost layers of cells dried down and turned brown or black (forming the false cicatrice described by Werner, (6) and suberization occurred in cells 6 to 8 or even 12 or more layers below the surface.

The statements made earlier in this paper about the need of picking up potatoes promptly after digging, in order to prevent heat injury, apply equally well for the prevention of skin browning. In fact, an exposure of skinned potatoes to drying winds for no more than 15 to 30 minutes has at times resulted in browning and stickiness that damaged the sale value of the shipment. Longer exposure causes correspondingly greater injury. Here again it should be remembered that browning may not become noticeable for several hours to a day after the potatoes are exposed to the drying conditions.

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HOT WATER FOR THE CONTROL OF POTATO RING ROT BACTERIA ON THE CUTTING KNIFE

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Introduction

The cutting knife, whether an ordinary knife or a rotary blade, is responsible for much spread of ring-rot bacteria [*Corynebacterium sepedonicum.* (Spieck, *et* Kott.) Skapt. and Burk.] to potato seed pieces during the cutting process. These bacteria may be killed quite effectively by the use of boiling water. The rotary knife may be sterilized by continuously running in a vat of boiling water while ordinary knives may be made sterile by dipping them in boiling water for short periods of time.

Experimental work

The control of ring-rot by the use of hot water was attempted cooperatively by Dr. D. P. Glick of the Colorado Agricultural Experi-

ment Station and the writer in 1942 in connection with a power-driven rotary cutting knife. However, the heating device was not adequate to maintain boiling temperatures in the large vat used, so no reliable results were obtained. Tests were conducted the same year by the writer to determine how hot the water must be in order to kill ring-rot bacteria in a given period of time. Likewise, similar tests were conducted in 1943.

Method of Making the Test: A cutting knife was drawn through ring-rot infected tubers and then dipped in the hot water, held at the desired temperature for the required period of time (usually 10 seconds), when it was removed immediately and used to cut a healthy tuber into halves. This process was repeated for each tuber cut until a total of 20 tubers were cut into halves, making 40 seed pieces for each type of test. These seed pieces were planted at the Agronomy Farm soon afterward in 10-hill rows, replicated 4 times. The subsequent plants were inspected for ring-rot symptoms several times during the season. Because of early frosts the plant symptoms were not thought to be so reliable as the stain method for determining ring-rot percentages, thus, the use of the latter in this paper. At the end of the growing season, one stem was selected from each hill and used in making stem smears on slides for subsequent staining and microscopic examination.

In 1942, the following water temperatures were used on the contaminated cutting knife for periods of 10 seconds: 200°F. (boiling), 192°, 182°, 172°, and 162°. Additional tests were made with boiling water for periods of 5, 10 and 15 seconds. In 1943, slightly different water temperatures were used, these being 200° F., 190°, 180°, 170°, 160° and 150°.

The results are shown in the table 1.

Summary and Discussion

Boiling water (200° F.) was effective in killing ring-rot bacteria on the cutting knife at exposures of 10 seconds although 5-second periods were not long enough. Temperatures lower than the boiling point were not so effective and the resulting percentages of ring-rot increased with the lower water temperatures used until at 150° F. no degree of control resulted.

The time element is important, particularly where rotary cutting knives are used, as the period between the successive seed pieces cut

TARLE I. *Table showing the effect of different water temperatures on the control of ring-rot bacteria on the cutting knife*

Water Temperature (Degrees Fahrenheit)	Length of Exposure (Seconds)	Per cent Ring-rot in Resulting Plants (Gram-stain Test)
1942		
200	10	0
192	10	5
182	10	25
172	10	50
162	10	80
200	5	60
200	10	5
200	15	0
Check (Inoculated)		95
Check (Not inoculated)		0
1943		
200	10	0
190	10	30
180	10	40
170	10	80
160	10	95
150	10	100
Check (Inoculated)		100
Check (Not inoculated)		0

is very short. Consequently, water should be kept at a boiling temperature for best results.

In these trials with hot water where a hot knife was used to cut the tubers, no reduction in stand or vigor of the resulting plant was observed.

SOIL FERTILITY EXPERIMENTS WITH POTATOES

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In 1938, the soil fertility experiments with potatoes at the Storrs Station were discontinued on Charlton fine sandy loam soil and relocated on Merrimac fine sandy loam soil at the recently purchased Vegetable-Agronomy farm. One of the chief reasons for the change was that larger acreages of commercial potatoes are grown on the Merrimac series. It is a water-formed soil, usually well-drained and free from large stones. The new site of the experimental potato plots is located in a small river valley in North Coventry,—seven miles west of Storrs. The untreated eight inches of top soil averages about four per cent

organic matter, pH 5.2, low to very low in easily soluble calcium, magnesium, phosphorus and potassium. This land had long been used as a general live-stock farm, except during the season of 1937, when the entire tillable area was planted to commercial potatoes.

The results of the experiments on Charlton and other soils have been published at the Storrs Station in Bulletins 203 and 223. They may be summarized briefly as follows: Under continuous culture on Charlton soil, maximum yields were obtained from 100 pounds of nitrogen, 160 pounds of phosphoric acid, and 120 pounds of potash per acre. When potatoes were alternated with clover and timothy, about one-half as much nitrogen and somewhat less phosphoric acid and potash resulted in the largest crops. In dry seasons, the potatoes yielded appreciably better under rotation than under continuous culture. No response was obtained to either lime or magnesia on the Charlton soil, but slight benefits from those nutrients were derived in a very few cases on other soil types, many of which were very low in those nutrients.

Additional experiments were planned to answer the following questions:

(1) Which are the best crops to grow in rotation with potatoes, for the purpose of maintaining the productivity of the soil?

(2) What amounts of nitrogen, phosphoric acid and potash are needed for maximum yields?

(3) Are elements other than nitrogen, phosphorus and potassium required in fertilizers for potatoes?

In the rotation experiment, potatoes were grown two years, with ten grass or legume crops the third season. Rye was seeded early in October following each crop of potatoes. Except for the summer annuals —soybeans and Japanese millet—the grasses and legumes were seeded without tillage in the very early spring following the second year of potatoes. Where early spring seedings were made, the rye was mowed when heading (late May) and allowed to remain on the ground. The grasses and legumes grew up through the rye and these were also mowed in August and left to decay.

The rye was plowed under for the soybeans and millet and these crops and also crimson clover were plowed under about the 1st of September, then rye was seeded again. Therefore, the plots in two systems (soybeans and Japanese millet) were plowed twice and one system (crimson clover) once, during the season not in potatoes, while in the others there were no tillage operations. No fertilizers were added to any of the green manure crops.

Each of the ten green manure systems was tested on triplicated

75x24 foot plots and including the two years in potatoes, a total of ninety plots and nearly four acres of land are required for this experiment. The experiment affords a comparison between first and second-year potatoes after each of ten green manure systems.

The same kind of fertilizer and also the same amount are used for the potatoes on all green manure plots and it is applied in bands by the planter at a rate that will furnish 100 pounds of nitrogen; 160 pounds of phosphoric acid; 120 pounds of potash; 90 pounds of lime; and 60 pounds of magnesia per acre. The lime and magnesia are supplied by dolomitic limestone.

So far, there have not been any marked differences in the yields of the potatoes on the various green manure plots. Redtop, although it made very little top growth, has been somewhat superior to red or crimson clover, timothy and the other crops. Soybeans and Ladino clover have evidently left more nitrogen in the soil for the potatoes, but the more luxuriant vine growth has resulted in smaller yields of tubers. Removing the mowed rye and also the red clover (as might be done on a farm to secure hay) has slightly reduced the subsequent yields of potatoes.

Although there have been very meagre differences between the individual green manure systems, in some seasons there have been quite striking differences between the first and second-year potatoes. For example, in 1941, all of the ten green manure systems produced more potatoes in the first than in the second year, the average difference being 63 bushels per acre. Again in 1942, the first year potatoes were better in nine of the ten cases,—the average difference giving a yield of 20 bushels per acre. In 1943, the two ranges were planted several days apart and therefore the results are not comparable.

Concerning the amounts of nitrogen, phosphoric acid and potash needed for maximum yields of potatoes under continuous culture with a rye cover crop each fall, ten different fertilizer treatments were tested on the same triplicated 75x18 foot plots for six years. In this experiment, a standard fertilizer, supplying 50 pounds of nitrogen, 80 pounds of phosphoric acid, 60 pounds of potash, 60 pounds of lime and 40 pounds of magnesia was applied in bands with the planter on *all* plots The additional fertilizers were added by hand in the shallow furrows left by the covering disks. The fertilizers added by hand were covered by harrowing down the ridges.

The yields, given in table I, indicate that no response has been obtained from the addition of more than 80 pounds of phosphoric acid. On the other hand, consistent increases have resulted from adding more

TABLE 1.—*Amounts of nitrogen, phosphoric acid and potash*

Treatment No.	Additions to "Standard" Fertilizer[1]	Total Bushels per Acre						
		1938	1939	1940	1941	1942	1943	Average Six Years
1	None	226	238	174	199	203	163	201
2	Nitrogen (N)	245	252	205	214	240	160	219
3	Phosphoric acid (P)	240	222	157	200	201	139	193
4	Potash (K)	241	268	250	229	245	196	238
5	N + P	259	239	168	223	234	174	216
6	N + K	252	281	197	260	273	208	245
7	P + K	265	239	174	239	233	196	224
8	N + P + K	295	285	231	239	276	160	248
9	N + P + KK	307	274	201	231	279	183	246
10	NN + P + KK	289	319	250	278	285	214	273

[1]The standard fertilizer supplied 50 pounds of nitrogen, 80 pounds of phosphoric acid, 60 pounds of potash, 60 pounds of lime, and 40 pounds of magnesia and is applied to all plots with the planter. In addition to the standard fertilizer, nitrogen is applied at 50 pounds, phosphoric acid at 80 pounds and potash at 60 pounds per acre with the exception of treatment number 9 where potash is added at 120 pounds and in number 10 where nitrogen is added at 100 pounds and potash at 120 pounds. (The abbreviations used above are not, in all cases, the chemical formulae for the nutrients).

TABLE 2.—*Effects of adding other elements to fertilizer containing only nitrogen, phosphoric acid and potash*

Treatment No.	Additions to Standard Fertilizer[1]	Total Bushels per Acre 1938	1939	1940	1941	1942	1943	Average Six Years
1	None	280	274	214	224	258	178	238
2	Limestone	283	291	260	213	237	165	242
3	Gypsum	316	269	220	232	258	158	242
4	Sodium sulphate	258	260	230	213	241	153	226
5	Magnesium Sulphate	278	299	207	252	276	202	252
6	Kieserite	296	299	216	217	292	159	247
7	Dolomitic limestone	295	285	231	239	276	160	248
8	Same as 7 + common salt	266	317	240	234	261	165	247
9	Same as 8 + manganous sulphate	315	262	176	221	249	122	224
10	Same as 9 + sodium tetraborate	268	276	177	218	229	128	216
11	Same as 10 + zinc sulphate	267	305	222	274	273	151	249
	Averages:							
	All with magnesium (7)	283	292	210	236	265	155	240
	All without magnesium (4)	284	274	231	221	249	163	237
	All with calcium (7)	287	286	218	233	255	150	241
	All without calcium (4)	278	283	217	227	267	173	241

[1]Standard fertilizer used contained a mixture of urea, ammophos and potassium nitrate. It was mixed and applied to furnish 100 pounds of nitrogen, 160 pounds of phosphoric acid and 120 pounds of potash per acre.

nitrogen or potash. The average increase from raising the nitrogen from 50 to 100 pounds was 18 bushels; from the second 60-pound increment of potash, 37; and from adding both nitrogen and potash, 44 bushels. The six-year average shows a further small gain from adding another increment of both nitrogen and potash, but only in one year (1939) was this treatment appreciably superior to all others in the experiment. It should be stated that the 1943 season was one of the driest in fifty-five years and a lack of water was the chief cause for the smaller yields that year.

In the third experiment, eleven different combinations of other elements were added to a standard fertilizer which supplied 100 pounds of nitrogen, 160 pounds of phosphoric acid and 120 pounds of potash per acre. The standard mixture was composed of urea, ammophos and potassium nitrate and contained only very small amounts of plant nutrients other than nitrogen, phosphoric acid and potash. This mixture was applied in bands with the planter, whereas the carriers of other elements were applied by hand in the shallow furrows left by the planter, excepting in 1943 when they were broadcast and disked into the soil. This change was made because there were indications that certain treatments were injurious when applied in bands near the potatoes.

The other elements added alone, or in combination in this experiment were: calcium, magnesium, sodium, manganese, zinc, chlorine and boron. Sulphur was ignored as it was carried by many of the materials and by the Bordeaux which, of course, also supplied considerable amounts of copper. Each year about 75 pounds of lime per acre were carried by the Bordeaux mixture.

The triplicated 75x18 foot plots received the same treatments in each of the six years during which the experiment has been conducted. Rye has been seeded in early October every fall and plowed under about the 1st of May, at which time it was approximately eight inches high.

As may be seen in table 2, the yields have not been increased appreciably by any combination of these elements. The vines on plots which received magnesium, have sometimes appeared more vigorous, but the average yield of the seven treatments with magnesium was practically the same as the four without magnesium. This was also true of calcium.

Summary

The potatoes yielded about the same after each of ten green manure systems. In some years, vine growth and yields were appreciably better during the first season than during the second—following the

green manures. It might be concluded, therefore, that the most important factor is to rotate potatoes with some other crop.

Under continuous culture for six years, our maximum yields were obtained from 100 pounds of nitrogen, 80 pounds of phosphoric acid, and 120 pounds of potash per acre. During the same period, adding carriers of calcium, magnesium, sodium, manganese, zinc, boron and chlorine to a fertilizer containing only nitrogen, phosphorus and potassium has not increased the yields.

SECTIONAL NOTES

CALIFORNIA

We have shipped by rail 12,889 cars of potatoes as compared with the rail shipments of 1943 on the same date of 13,336 and 10,203 on the same date for 1942. We reached a peak shipment by rail on the 31st of May of 803 cars per day and a second peak of shipments by rail on the 9th of June of 808 cars per day. The total rail shipments in the U. S. according to the Market News Service on the 9th of June was 1,180, of which Kern County shipped a total of 808 cars.

In addition to Kern County's shipments of 808 cars, Central California, according to the Market News Service shipped 23 cars by rail. This then means that Kern County is shipping more than 75 per cent of all the potatoes moving in the U. S. by rail. In addition to these rail shipments we are shipping by truck each day an average of nearly 100 cars.

Our labor supply at the present time is adequate, with approximately 9,000 workers in the fields, packing sheds, etc., for the harvesting and marketing of the crop. The I. C. C. Restriction on the use of refrigerator cars became effective Friday night and continued through Monday (June 12, 9:00 P. M.). It is rumored that Kern County will be permitted to ship potatoes only five days a week during the rest of the harvesting period. Motor truck shipments, however, will continue until some other order is issued.

Although the ceiling of U. S. No. 1 f.o.b. Kern County is $2.40, the market is not reaching the ceiling as U. S. No. 1 size A is selling from $2.25 to $2.50 per hundred. The yield of potatoes from Kern County this year will be below that of 1943, due primarily to the serious frost of the 15th of March, and, of course, to the old problem, that of poor seed. (June 13)—M. A. LINDSAY.

OREGON

Potato planting is now completed, with an acreage in the Klamath Basis estimated at 26,000 acres,—4 per cent more than last year. Generally speaking, the seed planted was of improved quality, with a great demand for the best certified seed available. The use of certified seed in the planting of our commercial acreage has increased considerably.

Since the temperature conditions during the spring were very low, our potato crop is slightly behind normal. Heavy frosts have occurred during the last ten days of May, but since the potatoes, generally speaking, had not emerged, the damage was slight. However the frost that occurred on the 12th of June did cause some damage. (June 15)—C. A. HENDERSON.

WASHINGTON

From all indications there appears to be a fairly substantial increase in the acreage of seed potatoes that will be entered for seed certification in 1944 in the state of Washington. This is rather interesting in view of the fact that there appears to be about a 20 per cent reduction in the commercial acreage that will be planted. (June 12)—CHAS. D. GAINES.

COLORADO

Shipments of Colorado potatoes are still continuing, although it is somewhat of a mystery where they are coming from. Car lot shipments to date are about 700 cars ahead of last year on the same date, and should make the government estimate correct.

The weather still continues unseasonably cool with enough rain to delay all field operations, so that the late plantings are following the precedent established by the earlier plantings and are being planted from a few days to two weeks later than usual.

Surveys of volunteer potato plants show a very heavy psyllid infestation, which, if the weather remains cool, should result in an approach to the epidemic of 1938. Growers with early plantings have been warned of the prospect, and spraying for control is now being started. (June 13)—C. H. METZGER.

CONNECTICUT

The acreage of potatoes planted in Connecticut has been reduced about fifteen per cent from the greatly expanded plantings of 1943, but is still above normal.

In May, the average temperature was far above normal, while the

precipitation was much below the usual amount. So far in June, there has been little rain and some potatoes are already suffering from lack of moisture.

The wireworm has become the worst pest for potatoes in Connecticut and some fields were not planted because of the serious damage caused in recent years by this uncontrollable insect. (June 9)—B. A. BROWN.

FLORIDA

Approximately 15,000 acres were planted to potatoes in the Hastings, Florida, section. The Sebago continued to gain in popularity as the acreage planted to this variety increased to 65 per cent as compared with last year when it was grown on 60 per cent of the acreage. The percentages of the acreage planted to other varieties are as follows: Katahdin, 28 per cent; Bliss, 5.5; Pontiac, 1.2; and Sequoia, 0.3 per cent.

The season was generally favorable for the growth of potatoes at Hastings until the 21st of March. Following that date, heavy rains fell for a period of 2 weeks, climaxed by a rainfall of 3.16 inches on the 3d of April. The total rainfall during this period amounted to nearly 9 inches and by the 20th of April, the plants in nearly all the potato fields had been killed by water damage and late blight. This had a marked effect on the yield as the growing season for the plants in most of the fields was reduced from 2 to 3 weeks. The average yield for the entire section is estimated at 100 bushels per acre, or about 25 per cent less than the average annual yield of 137 bushels for the 5-year period, 1939-1943.

Harvesting started about the 1st of April, and was completed about the 15th of May. Naturally on a few farms some difficulty was encountered in obtaining sufficient labor when needed.

Late blight and soft rot which developed during and immediately following the March-April rainy period caused losses estimated at 25 per cent of the crop. Many carloads of potatoes harvested during the first 2 weeks of April became severely affected with soft rot when the organism, *Erwinia carotovora* gained entrance into the tubers through enlarged lenticels, wounds, and lesions made by late blight. Decay was very great in some cars; one car was reported as containing 96 per cent decay. Prices declined sharply from $7.50 to $8.00 per cwt. for U. S. No. 1's on the leading markets at the beginning of the shipping season to $3.00 on the 20th of April, when many cars arrived in such condition that they had to be abandoned principally because there was not

sufficient labor at the market centers to recondition the potatoes. As the condition of the stock improved on arrival, prices advanced slowly and the potatoes were selling at approximately $5.00 per cwt. when the last shipments were made about the 15th of May.

Most of the decay occurred in those shipments of potatoes which were harvested when the fields were wet and the tubers washed and packed while still wet or moist. No hot air driers for drying washed potatoes are used in any of the packing houses at Hastings. If driers had been used, it is probable that little or no rot would have developed while the potatoes were in transit to market, provided the tubers showing decay had been sorted out at the shipping point.

Some growers avoided losses by delaying their harvesting operations until their fields dried out. Most of the tubers affected with late blight and soft rot in these fields decayed before they were dug or the diseases were so apparent at the packing houses that the affected tubers could be sorted out very easily.

Decay in potatoes harvested during the rainy period was generally less in shipments of non-washed potatoes. The amount of decayed tubers was greatest in potatoes that were grown in poorly drained fields. The decay was also generally greatest in shipments that were in transit for the longest period.

Observations made at Hastings in 1944, indicate that Bliss, Katahdin, and Sebago, grown in similar locations, dusted about the same number of times with copper lime dust for blight control, dug at approximately the same date and handled in the same manner at packing plants developed about the same amount of decay in transit. It would be a mistake to conclude that Sebago is more susceptible to late blight and soft rot than other varieties grown at Hastings in 1944. It is true that Sebago gave shippers more trouble than the other varieties but this was caused by the fact that more than 65 per cent of the potatoes grown were of the Sebago variety, and over two-thirds of the total number of cars shipped from Hastings contained potatoes of this variety. (May 29)—A. H. EDDINS.

IDAHO

Potato planting which should be nearly complete has been delayed by heavy rains which have been common throughout the entire state during the past two weeks. This will mean later planting than usual on a considerable acreage. Early fall frosts would mean an extremely short growing season in some parts of the state. This may mean smaller yields in some cases, but on the whole should bring some improvement in qual-

ity in the late plantings. Some reports of rhizoctonia injury in fields already planted have been called to our attention. On the bright side of the weather picture, the storms have insured a better irrigation season than was anticipated earlier in the year.

Acreage indications are still below those of last year. One county which grew 10,000 acres in 1943 will have around 6,500 acres in 1944. This is probably a bigger percentage decrease than the whole state acreage will show.

Increased acreages are still evident for certified seed plantings for this year, but late planting may again affect the yields. A considerable interest is being shown in War Approved Seed. This should not interfere with certified seed as it is coming mainly from growers who use certified seed yearly to grow the so-called "one-year-out" seed from which much of the Idaho crop is planted.

A late May frost in the Caldwell-Nampa area nipped the early crop in this district rather severely and may result in some decrease in yield. The main effect, however, will probably be in delaying the harvest for several days in this district.

There are still a few cars of table stock potatoes moving, with the total movement being somewhere near 39,000. This includes potatoes moved to dehydrators within the state. Idaho has experienced an exceptionally good year from the standpoint of demand and price. (June 15)—EUGENE W. WHITMAN.

INDIANA

With the exception of the southern area, our main crop of potatoes has been planted. The stands are good and the plants not only have a good color but are also growing well.

It has been necessary to fight to control the Colorado potato beetle as well as the leafhopper and flea beetle since there is a notable increase this year of all these pests.

The state, as a whole, is dotted with small plantings,—ranging from a few rows to one-half acre.

If the season remains favorable there will be little sale for outside potatoes this year. (June 10)—W. B. WARD.

KENTUCKY

Because of the extremely wet weather, when plowing should have been done there was delay, intensified by a sudden change to dry weather which made good seed bed preparation difficult. As a whole the crop was planted three weeks behind schedule. However, where the fields

received good care the final delay should be no more than one week or perhaps ten days. Harvesting should easily begin by the 4th of July.

Our stands are about 85 per cent as of today, the 12th of June; the condition of the crop about 80 per cent. Hot, dry weather is interfering with an increase in size, but fortunately the dry weather did not come until after the potatoes were set and well along. (June 12)—JOHN S. GARDNER.

MICHIGAN

Shipments for the season are about complete in Michigan. The carlot movement was quite orderly throughout the season except during December and the early part of January. The warehouse holdings in January seemed to indicate that Michigan would not ship as many cars as was estimated. However, later, when the farm-stored stock began to move, the shipments were brought above the estimation. The amounts of stock stored on the farms are always a good or poor guess when an attempt is made to see how much of it will grade out for shipment.

Government purchases for diversion brought out a lot of stuff. In fact, it brought out twos and culls that the growers have not been in the habit of selling. They were far from being disappointed in what they could get rid of on the diversion program.

Our certified seed movement for the season as a whole was good—practically all going for seed purposes. The War Approved seed deal was somewhat disappointing. Only a small percentage of it was used for seed.

Planting, in general, is about finished. However, in some of the late areas it will not be completed until the 20th of June. Indications are that there will be a slight increase in certified acreage and also a slight decline in table stock acreage. This decline in table stock acreage can be accounted for by the lack of new equipment and shortage of labor.

The season, as a whole, has been good to both growers and shippers. Every year has its problems, but this one will be recorded in history as having nearly everything that's in the books. A year that both growers and shippers will be glad to have behind them instead of in front of them. (June 12)—H. A. REILEY.

NEBRASKA

Since my last report regarding Nebraska conditions, considerable moisture has been received throughout western Nebraska,—the area which comprises the late main crop. During the past few days we have had ample to excessive rainfall. Severe hail storms have been experi-

enced, but generally, the damage has been caused by erosion and delay in planting.

Most of our growers are anxious to start planting by this time, but the saturated condition of the ground will prevent large scale operation from one to three days. Fields that were plowed ahead of planting will need additional work, to avoid excessive packing and difficulty in cultivation at a later date.

The central Nebraska plantings are progressing favorably, even though all plantings were quite late. With warmer weather, our early plantings will progress satisfactorily, and it is anticipated that the crop will make up for the delay.

Applications for certification, which, of course, are only tentative, indicate from a 10 per cent to 15 per cent increase in the acreage to be certified. More definite information on certified acreage will be available when planting is completed at the end of June.

All indications are that the acreage of commercial, that is, the non-certified acreage, will be reduced somewhat throughout this area. (June 15)—Marx Koehnke.

NEW JERSEY

The New Jersey crop is finally planted,—a large percentage of the acreage being planted during the first week of May. These late plantings have, in general, produced better stands than have the early plantings, and if relatively cool weather and sufficient moisture prevail during June many of these plantings will make rapid growth and a fair crop.

In some sections the heavy rains during April caused the seed to decay in the low areas, resulting in the loss of a considerable acreage.

The dry period between the 15th of May and the 10th of June retarded the growth of the crop to a certain extent. However, the showers we experienced on the 10th and again on the 14th of June have been of great benefit to our crop. Nevertheless, the acreage planted to potatoes in the southern part of the state is still in need of more moisture.

Our general harvesting operations will probably be from ten days to two weeks later than usual, and our crop prospects will be approximately 75 to 80 per cent of normal. (June 16)—J. C. Campbell.

NEW YORK

The Long Island potato crop was planted about as early as usual, with the ground in good condition. Conditions since that time have been favorable and the crop is fully as far advanced as usual.

The rainfall was very light for seven weeks,—from the latter part of April until the 10th of June,—but no extensive damage was done. The nice rain on the 10th of June will tend to favor the growth of the crop. Our crop is now coming into blossom, and all our stands are fully as good as usual. An average crop is now in prospect if we have adequate rainfall.

It is estimated that there is an increase in acreage because we planted some marginal land. (June 10)—H. R. TALMAGE.

Weather conditions for potato planting in Upstate New York have been generally very favorable. The April issue of "Crops and Markets" indicates a two per cent decrease in acreage for New York compared with that of 1943. Probably this slight decrease occurred among the smaller growers upstate. The Long Island acreage appears to be fully as good as that of last year. We note with considerable interest the fact that the principal decrease in potato acreage among the important late potato states this year is in the north-central states and in Idaho. With fertilizer sales apparently normal, it would now appear that whether the total crop will be above or below the record crop of 1943, will depend largely upon the weather. With a slight decrease in acreage among the late potato states, it can be safely predicted that the total crop will be somewhat less than that of last year.

There appears to have been some shift on Long Island from Green Mountains to Cobblers this year. This may be due to the poor market last spring for the crop stored later than usual for the Island. To this date Long Island is seriously in need of rain. The Cobbler crop in Nassau County was in full bloom last week, and the Green Mountains are almost at the blossoming stage at this time (June 14th). More and more growers on Long Island are installing portable irrigation equipment. Although this trend has been gradual and consistent for several years, the urge to irrigate is greatly stimulated by the lack of rainfall we experienced on the Island this spring.

It is reported that potato dehydrators have had considerable trouble with blackening of the dehydrated product. In fact the difficulty was so serious that some of the plants closed down for lack of suitable raw material. Both local stocks and Maine potatoes were unsatisfactory. This difficulty may have been accentuated at this time because of the late planting and late maturity of last year's crop. (June 4)—E. V. HARDENBURG.

VIRGINIA

The Virginia potato area has experienced the worst drought in its history. Practically no rain has fallen during the past six weeks. The rainfall at Diamond Springs in Princess Anne County was eighty-eight hundredths of an inch in May and at Onley in Accomac County, sixty-seven hundredths. No rain fell during the latter part of April and practically none has fallen to date in June. Temperatures during May were about six degrees above normal and have also been above normal in June. Because of the extremely wet weather in March much of the acreage was planted late and on soils that were too wet for planting. This resulted in many instances in a rather hard condition of the soil. This, in addition to the drought has caused severe injury to the potato crop. Yields will be as low as ten bags of U. S. No. 1 grade to the acre in some fields to possibly eighty bags in the best fields which were not irrigated. Irrigated fields, comprising a few hundred acres, will probably yield in excess of one hundred bags to the acre. It is estimated that the average yield will be approximately forty bags to the acre for Eastern Virginia. (June 14)—H. H. ZIMMERLEY.

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STUDIES ON POTATO NUTRITION: I. THE EFFECTS OF FERTILIZER TREATMENT ON THE YIELD AND COMPOSITION OF KERN COUNTY POTATOES

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Introduction

Kern County potatoes vary greatly in yield and quality with different fertilizer treatments. Few published data dealing with their composition and quality are available. Kern County is a new, rapidly expanding potato area, the acreage having increased from 2,200 acres in 1930 to 8,850 in 1935; to 36,000 in 1940; and to an estimated 60,000 acres in 1944. The yields per acre rank with the highest reported anywhere in the United States. From April to June, inclusive, over one-half of the rail shipments of new potatoes in the United States originate there. This paper deals with the effect of certain fertilizer treatments on the yield and composition of Kern County potatoes.

Materials and Methods

The results reported were obtained during the spring of 1942 from two fertilizer experiments—one at the U. S. Cotton Experiment Station at Shafter; the other at the Ben Sill Ranch at Saco. The soil at the first-mentioned location is classified as Hesperia sandy loam; and that at the second location as Delano fine sandy loam. The fertilizer treatments in the Cotton Station Experiment were superimposed on plots that had received those fertilizer treatments for two previous years, whereas the plots at the Sill Ranch were on land that was being cropped for the first time. Seed of the White Rose variety was planted at the Cotton Station plot on the 27th of February; at the Sill plot on the 30th

of January. Approximately 1400 pounds of seed were planted per acre. The fertilizer was applied at the time of planting—2 inches on each side and about 1 inch below the seed pieces. The plants were cultivated when approximately 6 inches tall. Daily irrigations in alternate furrows were then begun and were continued until one week before harvest,—the usual practice for potatoes in this section. The plot at the Cotton Station was harvested on 18th of June; that at the Sill Ranch on the 4th.

Table 1 lists fertilizer treatments that compared the rates of application of nitrogen, phosphorus, and potash in the experiment at the Cotton Station; table 3, those at the Sill Ranch. All the nitrogen was derived from ammonium sulfate; the potash from potassium sulphate. The superphosphate used to supply phosphorus contained 32 per cent P_2O_5. Every treatment at the Cotton Station consisted of 6 plots, each plot containing four harvest and two guard rows 90 feet long. The treatments at the Sill Ranch were replicated four times, each plot consisting of two harvest rows 125 feet long.

The methods used for the soluble-nutrient analyses were essentially those outlined by Carolus (1938) and already reported by the author (Lorenz and Minges, 1942). Petiole tissue of the second or third youngest leaf from the tip of the plant was extracted with 2 per cent acetic acid, a Waring Blendor being used to macerate the tissue. The total-nutrient analyses were conducted according to A. O. A. C. methods except for potassium, which was determined by the Cobaltinitrite

TABLE 1—*Effect of fertilizer treatment on yield, grade and quality of potatoes grown at the Cotton Station*

Fertilizer Treatment (Pounds per Acre)			Yields in 100-Pound Sacks per Acre		
N	P_2O_5	K_2O	Total Yield	U. S. No. 1	Starch as Per Cent of Fresh Weight
0	128	150	233	142	17.0
52	128	150	382	240	15.6
105	128	150	412	258	14.4
157	128	150	425	264	12.8
210	128	150	398	219	13.0
210	128	0	412	233	12.2
210	128	75	414	234	13.2
210	0	150	382	224	13.0
210	64	150	391	228	12.6
Difference required odds 19:1			31	43	

method. Starch was not determined directly, but was calculated from specific gravity measurements of the tubers according to the formula given by Blood and Prince (1940). Duplicate samples for nutrient analysis were taken from each of two replicates of each fertilizer treatment.

TABLE 2—*Effect of fertilizer treatment on soluble-nitrogen, phosphorus, and potassium content of potatoes grown at the Cotton Station*

	Fertilizer Treatment (Pounds per Acre)			Soluble Nutrients in Petiole Tissue on the Following Dates— (Fresh Weight Basis)		
	N	P_2O_5	K_2O	4/15	4/28	5/27
				Nitrate as ppm N		
1.	0	128	150	897	324	9
2.	52	128	150	1364	849	9
3.	105	128	150	1444	1296	11
4.	157	128	150	1421	1301	174
5.	210	128	150	1545	1373	305
6.	210	128	0	1506	1480	351
7.	210	128	75	1583	1413	328
8.	210	0	150	1519	1404	361
9.	210	64	150	1582	1415	275
				Phosphorus as ppm P		
1.	0	128	150	225	328	82
2.	52	128	150	242	289	148
3.	105	128	150	281	311	173
4.	157	128	150	265	286	141
5.	210	128	150	252	286	290
6.	210	128	0	272	303	315
7.	210	128	75	272	286	255
8.	210	0	150	52	69	23
9.	210	64	150	214	246	155
				Potassium as ppm K_2O		
1.	0	128	150	14300	17795	21145
2.	52	128	150	13295	17600	19975
3.	105	128	150	12770	17755	20125
4.	157	128	150	12975	16275	18150
5.	210	128	150	14395	18235	15990
6.	210	128	0	10575	15855	12690
7.	210	128	75	14375	16320	18375
8.	210	0	150	14030	18650	20925
9.	210	64	150	10590	17865	20145

Results

Effect on Yield and Soluble-Nutrient Content

As table 1 shows, nitrogen was the most important fertilizer element affecting yield in the Cotton Station experiment. The total yield of tubers was increased from 233 sacks where no fertilizer was used to 382 sacks where 52 pounds of nitrogen were applied per acre. Only a slight increase in yield resulted from rates of application higher than 52 pounds per acre. The differences in the yield of U. S. No. 1 potatoes were similar to those for total yield. The starch content of the tubers decreased from 17 per cent where no nitrogen was used to 15.6 per cent for potatoes receiving 52 pounds of nitrogen per acre and reached a low of approximately 13 per cent for potatoes receiving 157 pounds or more. There were possibly slight increases in yield due to phosphorus fertilization as compared with the yield on plots lacking phosphorus. Potassium, however, definitely did not affect either the yield or the starch content. The results obtained in 1942 compare well with those obtained during the two previous years of this investigation.

Table 2 shows how the fertilizer treatments affected the soluble-nitrogen, phosphorus, and potassium content of petioles of potatoes grown at the Cotton Station. At the first sampling date on the 15th of April, or about 3 weeks after the plants had emerged, only those grown without nitrogen showed any differences in nitrate content. By the 28th

Table 3—*Effect of fertilizer treatment on yield and soluble-nitrogen, phosphorus, and potassium content of potatoes grown at the Sill Ranch*

Fertilizer Treatment (Pounds per Acre)			Total Yield of 100-Pound Sacks per Acre	Parts per Million Soluble Nutrients in Petiole Tissue on the Following Dates (Fresh-Weight Basis)					
				Nitrate as N		Phosphorus as P		Potassium as K_2O	
N	P_2O_5	K_2O		4/15	5/28	4/15	5/28	4/15	5/28
0	0	0	174	732	16	154	25	15770	16960
60	0	0	251	1014	19	101	22	14780	17700
120	0	0	323	984	145	120	17	15950	17345
180	0	0	321	1223	373	93	15	16470	15780
120	150	0	258	1085	87	273	85	14790	18530
120	150	150	253	1095	27	324	78	15180	18145
Diff. required odds 19:1			80						

of April, such plants contained only about one-fourth as much soluble nitrate as those fertilized with 105 pounds or more of nitrogen per acre, whereas those receiving 52 pounds per acre were intermediate. By the 27th of May the nitrate content of all the plants dropped considerably regardless of the rate of application; and only in plants receiving 157 pounds or more of nitrogen per acre was there any appreciable amount of nitrate.

The soluble-phosphorus content of the plants was much lower on plots not receiving phosphorus than on plots supplied with it. This was true at all three dates of sampling. At the last sampling, the plants lacking nitrogen were very low in total phosphorus content as well as in soluble phosphorus. (See table 5).

The soluble-potassium content of the plants was extremely high at all stages of growth, even on plots lacking potassium additions. In most treatments the soluble potassium increased as the plants approached maturity.

Table 3 gives data on yield and soluble-nutrient content of the plants grown in the experiment at the Sill Ranch. The yield of tubers was increased by applying 60 pounds of nitrogen per acre as compared with plants grown without nitrogen fertilizer. The data do not justify conclusions as to whether application in excess of 60 pounds of nitrogen per acre increased yield. The soluble-nutrient analyses made on the leaf petioles showed the nitrate content to be the lowest in plants not supplied with nitrogen. Phosphorus additions apparently had no effect on yield as compared with the yield of plots lacking phosphorus. The soluble-phosphorus content was approximately three times higher, however, in plants supplied with phosphorus. Potassium fertilization had no effect on yield; and the soluble potassium was very high in all plants, even those not given potassium.

Effect on Dry Matter Composition

Tables 4 and 5 show the effect of location and certain of the fertilizer treatments on moisture, nitrogen, and the more important ash constituents. Except for moisture the data are expressed on the basis of dry-weight determinations. The plants were divided into leaf blades, stems and petioles, roots, and tubers. The first samples were taken from the Cotton Station plot on the 15th of April or about 3 weeks after the plants had emerged. At this time tuberization had just commenced, but there were not yet sufficient tubers available for analysis. Samples of the leaves, stems, and roots were again taken on the 28th of April and the 28th of May. Tuber samples were taken at both of these

TABLE 4—*Effect of location and fertilizer treatment on dry weight as per cent of fresh potatoes at successive stages of growth*

Location and Pounds of N, P_2O_5, and K_2O Applied per Acre		Dry Weight as Per cent of Fresh												
		Leaf Blades			Stems and Petioles			Roots			Tubers			
		4/5	4/28	5/28	4/5	4/28	5/28	4/5	4/28	5/28	4/5	4/28	5/28	6/18
	$N-P_2O_5K_2O$													
Cotton Sta.	0 -128-150	13.4	12.8	13.1	6.6	7.1	8.4	7.8	13.5	15.8	..	13.3	20.7	24.5
	105-128-150	13.9	12.8	11.8	6.7	6.1	7.9	7.3	9.3	13.2	..	12.5	17.7	21.6
	210-128-150	14.1	12.7	12.4	7.0	6.0	8.1	7.0	8.5	12.6	..	9.1	16.6	21.0
	210-128- 0	14.8	13.2	12.1	6.9	5.8	8.6	6.9	11.2	14.1	..	10.7	17.1	21.1
	210- 0 -150	15.4	13.3	11.4	7.6	6.0	8.2	7.5	9.3	14.0	..	12.6	16.2	20.6
Sill Ranch	120-150- 0	11.4	14.3	16.2	5.1	8.5	8.5	10.1	11.8	13.3	12.2	14.8	19.4	..

TABLE 5—*Effect of location and fertilizer treatment on the nutrient content of potatoes at successive stages of of growth; data expressed on dry weight basis*

Location and Pounds of N, P_2O_5, and K_2O Applied per Acre		Leaf Blades			Stems and Petioles			Roots			Tubers			
		4/5	4/28	5/28	4/5	4/28	5/28	4/5	4/28	5/28	4/5	4/28	5/28	6/18
	$N-P_2O_5K_2O$	Per cent Nitrogen (N)												
Cotton Sta.	0 -128-150	4.84	4.75	3.13	3.42	1.86	.85	2.56	1.52	.94	..	1.23	.78	.87
	105-128-150	5.79	6.24	4.34	4.22	3.86	1.33	3.31	2.93	1.45	..	2.07	1.25	1.29
	210-128-150	5.78	6.40	4.88	4.14	3.84	2.00	3.73	3.22	2.06	..	2.55	1.70	1.76
	210-128- 0	5.52	6.36	4.66	4.29	3.69	1.82	3.78	2.85	1.75	..	2.11	1.69	1.55
	210- 0 -150	5.51	5.19	4.71	4.01	3.54	2.00	3.55	3.07	1.84	..	2.46	1.74	1.70
Sill Ranch	120-150- 0	4.69	4.92	3.25	4.24	2.68	1.56	2.91	1.89	1.41	1.77	1.59	1.37	
		Per cent Phosphorus (P)												
Cotton Sta.	0 -128-150	.49	.46	.26	.57	.55	.28	.58	.51	.24	..	.35	.24	.24
	105-128-150	.58	.64	.41	.73	.71	.49	.81	.67	.52	..	.38	.32	.33
	210-128-150	.59	.70	.48	.71	.72	.55	.82	.65	.59	..	.44	.32	.32
	210-128- 0	.57	.71	.44	.70	.79	.50	.78	.69	.54	..	.40	.32	.29
	210- 0 -150	.47	.44	.29	.34	.39	.21	.25	.27	.21	..	.30	.26	.24
Sill Ranch	120-150- 0	.58	.42	.26	.81	.41	.18	.61	.37	.18	.36	.29	.27	
		Per cent Potassium (K)												
Cotton Sta.	0 -128-150	4.14	4.93	4.86	8.74	8.29	7.92	6.10	3.66	2.76	..	2.64	2.24	1.98
	105-128-120	3.86	4.96	4.60	8.60	8.62	8.70	5.99	4.44	2.72	..	2.66	2.11	2.18
	210-128-150	3.97	4.64	4.80	8.29	8.10	7.88	6.10	4.72	2.66	..	3.17	2.26	2.33
	210-128- 0	3.82	4.57	4.54	8.08	8.42	6.30	6.09	3.84	2.21	..	2.38	2.04	1.96
	210- 0 -150	3.91	4.66	4.72	8.48	9.22	7.64	5.81	4.23	2.41	..	2.88	2.18	2.15
Sill Ranch	120-150- 0	4.35	4.57	4.04	7.83	7.13	6.51	3.80	3.40	2.24	2.47	2.33	2.36	

TABLE 5—*Continued—Effect of location and fertilizer treatment on the nutrient content of potatoes at successive stages of growth; data expressed on dry weight basis*

Location and Pounds of N, P_2O_5, and K_2O Applied per Acre		Leaf Blades			Stems and Petioles			Roots			Tubers			
		4/5	4/28	5/28	4/5	4/28	5/28	4/5	4/28	5/28	4/5	4/28	5/28	6/18
	$N-P_2O_5K_2O$	Per cent Magnesium (Mg)												
Cotton Sta.	0 -128-150	.80	.86	.60	.63	.48	.72	.46	.36	.50	..	.12	.12	.13
	105-128-150	.65	.68	.56	.62	.52	.49	.46	.58	.46	..	.12	.12	.14
	210-128-150	.59	.70	.77	.58	.56	.64	.50	.57	.53	..	.15	.12	.14
	210-128- 0	60	.79	.77	.67	.71	.80	.61	.58	.50	..	.13	.11	.13
	210- 0 -150	.57	.69	.55	.58	.57	.46	.53	.65	.48	..	.17	.13	.14
Sill Ranch	120-150- 0	.83	.91	.86	.82	.89	1.25	.63	.59	.64	.12	.13	.14	
		Per cent Calcium (Ca)												
Cotton Sta.	0 -128-150	1.62	2.27	3.13	2.07	2.01	2.71	1.87	1.67	1.62	..	.148	.053	.039
	105-128-150	1.24	1.68	1.98	1.80	1.46	1.43	1.48	1.46	1.46	..	.181	.045	.039
	210-128-150	1.00	1.62	1.78	1.68	1.59	1.36	1.28	1.41	1.24	..	.180	.044	.040
	210-128- 0	1.15	1.76	2.10	1.75	1.65	1.38	1.50	1.35	1.30	..	.146	.041	.038
	210- 0 -150	1.55	1.50	1.58	1.57	1.37	1.08	1.51	1.53	1.37	..	.234	.052	.041
Sill Ranch	120-150- 0	1.49	1.89	2.38	1.46	1.47	1.80	1.38	1.16	1.32	.157	.088	.049	
		Per cent Ash												
Cotton Sta.	0 -128-150	34.3	20.1	25.6	32.6	25.1	26.2	18.1	12.8	11.7	..	5.47	4.30	4.29
	105-128-150	27.8	18.6	20.4	28.3	24.4	21.5	16.9	15.7	12.4	..	5.85	4.30	4.58
	210-128-150	28.9	18.0	19.2	28.0	25.0	20.8	17.2	14.9	12.0	..	6.32	4.48	4.47
	210-128- 0	31.8	17.8	17.7	31.5	24.4	18.4	17.3	15.1	13.6	..	5.65	4.09	3.97
	210- 0 -150	24.8	18.1	19.1	26.2	25.4	20.4	16.4	15.3	12.7	..	6.46	4.48	4.40
Sill Ranch	120-150- 0	30.7	20.0	27.1	25.5	21.5	20.8	14.9	13.9	11.9	5.45	5.63	4.69	

latter dates as well as at time of harvest on the 18th of June. The leaves, stems, and roots were not sampled on the 18th. The top portions of the plants had matured and dried, making it impossible to obtain a representative sample. According to periodic sampling, tubers increased from 350 to only 400 sacks per acre from the 28th of May to the 18th of June—a fact indicating that the plants were quite mature as early as the 28th of May. In fact, many commercial fields are harvested at less than 100 days after planting, a date which would roughly correspond to the sampling on the 28th of May. The samples from the Sill Ranch were taken from a portion of a commercial field adjacent to the fertilizer test previously reported. The potatoes had been fertilized, at time of planting, with 120 pounds of nitrogen and 150 pounds of phosphoric acid per acre.

Dry Matter. The dry-matter content of the leaf blades of plants grown at the Cotton Station decreased with age except in the treatment lacking nitrogen, where there was no change. The leaves from the plants at the Sill plots increased in dry matter with age. In the stems the dry-matter content was highest in the samples taken on May 28. In the roots of plants from the Cotton Station plots, dry matter increased from about 7 per cent at the first sampling on the 5th of April to about 13 per cent on the 28th of May. At all sampling dates, plants given no nitrogen had more dry matter in the roots than plants supplied with nitrogen. Roots of plants from the plots at the Sill Ranch also increased in dry matter with maturity. In the tubers from the Cotton Station

TABLE 6—*Effect of nitrogen on the dry matter, nitrogen, and ash constituents of potato tubers grown at Cotton Station; data expressed on fresh-weight basis*

Pounds of N, P_2O_5 and K_2O Applied per Acre	Date of Sampling	Per cent of Fresh Weight						
		Dry Matter	N	P	K	Ca	Mg	Ash
N P_2O_5 K_2O								
0-128-150	4/28	13.3	.164	.047	.351	.020	.016	.728
	5/28	20.7	.161	.050	.464	.011	.024	.890
	6/18	24.5	.213	.059	.485	.010	.032	1.051
210-128-150	4/28	9.1	.232	.040	.288	.016	.014	.595
	5/28	16.6	.282	.053	.375	.007	.020	.743
	6/18	21.0	.370	.067	.489	.008	.029	.939

plots, the dry matter practically doubled between the first sampling and the last, which was at the time of harvest. At harvest the dry-matter content of the plants grown without nitrogen was 24.5 per cent, as compared with about 21 per cent for plants supplied with 210 pounds of nitrogen per acre.

Nitrogen. Nitrogen in the leaves was somewhat lower at all stages of plant growth on plots without nitrogen than on plots receiving 105 to 210 pounds per acre. The same was true for the nitrogen content of the stems and petiole: at the first sampling the per cent nitrogen in the stems was 3.4 in plants given no nitrogen, as compared with more than 4.0 for plants receiving nitrogen. On the 28th of May, stems of plants grown on the plots lacking nitrogen fertilizer analyzed 0.85 per cent, whereas plants grown on plots receiving 105 to 210 pounds of nitrogen per acre contained 1.33 and 2.00 per cent nitrogen, respectively. The omission of phosphorus or potassium did not affect nitrogen absorption. In the roots nitrogen decreased appreciably as the plants matured. Roots from the plots lacking nitrogen contained only about one-half as much nitrogen as those on plots receiving 210 pounds per acre.

Tubers from plants of all the treatments decreased in nitrogen content with maturity. This decrease was nearly the same in proportion as the increase in dry-matter content. Mature tubers of plants grown on the minus-nitrogen plots contained 0.87 per cent nitrogen, as compared with 1.29 and 1.70 per cent for those grown on plots receiving 105 and 210 pounds per acre, respectively. Although the dry-matter content of the tubers was somewhat higher on plots lacking nitrogen than on plots supplied with it, the differences in dry matter were not nearly so great as the differences in nitrogen content. Tubers from the Sill plots contained approximately the same amount of nitrogen as those fertilized with 105 pounds of nitrogen per acre in the Cotton Station experiment.

Phosphorus. The phosphorus content of all the plant parts was influenced both by nitrogen and by phosphorus fertilization. The omission of nitrogen from the fertilizer reduced the absorption of phosphorus by the same amount as did the omission of phosphorus. In the leaf blades of plants grown without nitrogen, phosphorus was much lower than in plants supplied with nitrogen. Similar differences in phosphorus content were noted by comparing plants grown on plots lacking and those receiving phosphorus fertilizer. At the last sampling on the 28th of May, leaves of plants on plots without nitrogen contained 0.26 per cent phosphorus, as compared with 0.29 on plots without phosphorus and about 0.40 on plots receiving both nitrogen and phosphorus.

Although the phosphorus content averaged slightly higher in the stems and roots than in the leaves, the differences in phosphorus absorption between the plants lacking either nitrogen or phosphorus and those supplied with these elements still prevailed. In the mature tubers the phosphorus content was 0.24 per cent on plots lacking either nitrogen or phosphorus, as compared with about 0.30 on plots supplied with them. The phosphorus content of the tubers decreased markedly from the 28th of April to the 28th of May, but showed little change with time after the latter date. The plant parts of the samples from the Sill plots were comparable in composition with those grown on the plots lacking phosphorus at the Cotton Station—a fact suggesting that the soil on which they were grown was low in available-phosphorus content. The soluble-nutrient analyses presented earlier give support to this suggestion.

Potassium. The potassium content of all the plant parts was high. At the last sampling date, however, potassium was lower in all parts of the plants grown on plots lacking potassium than in plants on plots receiving it. The potassium content of the leaf blades was slightly less than 4.0 per cent on the 5th of April and increased to slightly over 4.5 per cent in the samples taken on the 28th of May. In the stems and petioles the potassium content averaged about 8.0 per cent throughout growth. Samples from some treatments showed a slight decrease with age, whereas in the roots potassium decreased from approximately 6.0 per cent in the samples taken on the 15th of April to about 2.5 per cent for the sample on the 28th of May. In the tubers the potassium content was variable, but decreased from slightly less than 3.0 per cent for samples taken on the 28th of April to nearly 2.0 per cent for the samples taken at harvest. The analyses of the samples taken at the Sill Ranch were comparable with those at the Cotton Station; but the roots may have tested slightly lower in potassium at the earliest sampling.

Magnesium. The magnesium content of the plants grown at the Cotton Station was not influenced by any of the fertilizer treatments given and did not show any consistent trends with age. In the leaf blades, magnesium varied from 0.55 to 0.86 per cent. Comparable analyses in the stem ranged from 0.46 to 0.80 per cent; in the roots from 0.36 to 0.61; and in the tubers from 0.11 to 0.14. The plants grown on the Sill plots showed slightly higher magnesium in the leaves, stems, and roots, but were about the same in the tubers.

Calcium. At the Cotton Station plots calcium was highest in the plants given no nitrogen as judged by the leaves, stems, and roots. There was, however, no difference in the tubers. In the leaves at the

last sampling, plants grown without nitrogen contained 3.13 per cent calcium, as compared with less than 2.00 per cent for plants receiving 105 to 210 pounds of nitrogen per acre in addition to phosphorus and potassium; 1.58 per cent for plants receiving nitrogen and potassium but lacking phosphorus. In the stem tissue, the plants grown on plots lacking phosphorus contained the least calcium. At the last sampling, for example, the stems of plants grown without nitrogen contained 2.71 per cent calcium, as compared with 1.36 for plants supplied with 210 pounds of nitrogen per acre and 1.08 for plants to which no phosphorus was applied. The roots showed no noticeable changes in calcium content and averaged about 1.40 per cent. The increased calcium content of the leaves and stems of plants fertilized with phosphorus may have been due to the application of calicum contained in the phosphorus fertilizer rather than to any effect of phosphorus as such, even though treble superphosphate containing 32 per cent P_2O_5 was used. The soil on which these plants were grown is known to be very low in calcium and high in sodium.

The tubers were very low in calcium. The first samples taken on the 28th of April or very soon after tuberization had begun averaged 0.146 to 0.234 per cent calcium, whereas the mature tubers contained 0.039 to 0.041 per cent. The tubers taken from the Sill plots at time of harvest were slightly higher in calcium than those at the Cotton Station; the fact that they were slightly more immature may, however, account for the difference.

Ash. The per cent ash of samples from the Cotton Station plots was higher in every case in the first samples than in those taken from the more mature plants or tubers. Leaves of the plants given no nitrogen were higher in ash than the leaves of plants receiving nitrogen. The omission of phosphorus from the fertilizer did not appreciably alter the ash content of any of the plant parts, whereas in the last samples taken the leaves, stems, and tubers from plots without potassium were slightly lower in ash content. The tubers contained slightly over 4 per cent ash, as compared with about 12 per cent in the roots and about 20 per cent in the more mature leaves and stems. Samples from the Sill plots showed comparable results.

Table 6 presents data showing the effect of zero and high nitrogen additions on the composition on a fresh weight basis of tubers grown at the Cotton Station. These two treatments showed the extremes both in yield and composition of the tubers. Tubers produced on the plots receiving nitrogen were much higher in nitrogen at all stages of growth, slightly higher in phosphorus at the latter stages, about equal in potas-

sium, and slightly lower in calcium, magnesium, and ash. In tubers from both nitrogen treatments, all of the constituents analyzed, except calcium, were higher in the mature tubers than samples taken on either the 28th of May or the 28th of April. Calcium was only about one-half as high in the samples taken on the 28th of May or the 18th of June as on the 28th of April.

Discussion and Summary

Yield and nutrient-analyses studies were made of White Rose potatoes grown in two fertilizer experiments in Kern County, California in the spring of 1942. Nitrogen was the predominating fertilizer element affecting yield, although phosphorus may have given a slight response. Applications of 52 pounds of nitrogen per acre increased the yield from 233 to 382 sacks per acre in one test, whereas 60 pounds increased the yield from 174 to 251 sacks in the other. Higher rates of application than these may be beneficial. Potash applications had no effect on yield.

Analyses of soluble nutrients in the petiole tissues indicate that if the plants contain less than 800 parts per million of nitrate approximately one month after emergence the yield will be depressed. This agrees well with the data given by Carolus (1937) which indicates that a minimum soluble-nitrogen content of 700-800 parts per million should be maintained. Nitrates decreased rapidly as the plants matured. During the most rapid period of growth in the plants on plots without phosphorus, soluble phosphorus was less than 70 parts per million. This level may have been associated with a slight reduction in yield. Carolus found that a minimum soluble-phosphorus content of 150 at the beginning and 60 parts per million at the close of the season was necessary for maintaining high yields. This would indicate that the Kern County plots were near a critical phosphorus level. Soluble potash never ranged less than 10,000 parts per million which was about 3 times the minimum potash content of 2,200 at the beginning and 4,500 parts per million at the end of the season, suggested by Carolus.

The starch content decreased from 17.0 per cent for tubers produced without nitrogen to less than 13 per cent for tubers grown on plots receiving 210 pounds of nitrogen per acre.

Total nutrient analyses are given for the leaves, stems, roots, and tubers of samples taken throughout the season from some of the fertilizer treatments: Nitrogen was lower in all parts of the plants grown on the plots lacking nitrogen than in plants on plots receiving nitrogen. Phosphorus was low both in plants grown without nitrogen and in those without phosphorus. The omission of nitrogen from the fertilizer greatly

reduced the absorption of phosphorus by all parts of the plant analyzed. Potassium was high in all samples and was unaffected by any of the fertilizer treatments. Calcium was highest in plants grown without nitrogen and lowest in plants grown without phosphorus. Total ash accumulated in the top portions of the plants grown without nitrogen.

Mature tubers harvested from plots liberally fertilized contained the following expressed as per cent of fresh weight; dry matter, 21.0; nitrogen, 0.037; phosphorus, 0.067; potassium, 0.489; calcium, 0.008; magnesium, 0.029; and ash, 0.939.

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POTATO BREEDING, WHITHER BOUND?

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The national potato-breeding program has been in operation for 14 years, and it might be profitable at this time to take stock of what has been accomplished and to outline at least in general terms the plans for future work.

The practice under this program has been to send seedling varieties produced by the United States Department of Agriculture or by any of the cooperating state experiment stations to various other states for trial. If after sufficient tests any seedling shows superiority to the standard varieties in at least one important character, such as yield, market quality, or resistance to a disease that is difficult or in some cases impossible to control, it is named and released to growers in the section to which it is adapted. As a result of this work, 17 new varieties have been distributed during the 11-year period just passed. Thirteen of these appeared on the certified seed-potato lists for 1943,

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(table 1). Two are so new that only a few bushels of seed are available for planting in 1944, and the remaining 2 seem to have gone out of production.

If the certified seed production is taken as a criterion, Katahdin is the most extensively grown late variety in the United States. It surpasses its nearest competitor, Green Mountain, by nearly 50 per cent. In addition to the 4,675,898 bushels certified in the United States in 1943 (table 1), 1,091,000 bushels of this variety were certified in the maritime provinces of Canada. This represents 34 per cent of all the certified seed grown in New Brunswick, Nova Scotia, and Prince Edward Island. Chippewa is not so widely adapted and is more difficult to grow than Katahdin, but 1,212,979 bushels of certified seed of Chippewa are available for the 1944 crop. This is a decrease from the amount grown in 1942. Sebago has shown the most spectacular increase. Seed of this variety was sold to growers for the first time in the fall of 1938, and 1,643,657 bushels of certified seed

TABLE 1.—*New varieties of potatoes released under the national potato-breeding program, the year each was released, and the amount of certified seed grown in the United States in 1943.*

Variety	Year Released	Amount of Seed Certified in the United States in 1943	
		Bushels	Per cent
Katahdin	1932	4,675,898	16.10
Chippewa	1933	1,212,979	4.18
Warba	1933	169,686	.58
Golden	1933	....	....
Houma	1936	203,380	.70
Earlaine	1937	....	....
Sebago	1938	1,643,657	5.66
Earlaine 2	1938	70,472	.24
Pontiac	1938	129,051	.44
Mesaba	1938	9,525	.03
Sequoia	1939	146,372	.50
Red Warba	1939	156,877	.54
Erie	1942	1,530	.00+
Pawnee	1942	21,364	.07
Mohawk	1943	500[1]	.00+
Kasota	1943	15,110	.05
Potomac	1943	500	.00+
Total new varieties in the United States		8,456,901	29.09
Total for all varieties in the United States		29,044,868	100.00

[1]Estimate of seed available but not found on certified lists.

were produced in the United States in 1943. Golden and Earlaine are not found on the certified seed lists, and Houma shows a small decrease from 1942, but all the others are on the increase.

No variety has been distributed to growers that will meet the needs of all the cooperating states, and it is doubtful if such an ideal variety will be produced in the near future. There was, however, a sectional demand for each one of the new varieties, and they have been increased against hard competition and severe criticisms, because of special characters that give them a definite advantage over the old varieties. The Katahdin got its start in Michigan when it was found that under unfavorable growing conditions in the latter part of the growing season it would outyield the Rurals. The Chippewa, because it was somewhat earlier than the Katahdin, became a competitor in Michigan and spread to Wisconsin and Minnesota. Maine was interested at first in these two varieties from the standpoint of seed production for other states, but during the severe epidemics of net necrosis in the Green Mountain variety from 1938 to 1942, inclusive, the two new varieties increased for table stock production very rapidly, because neither of them develops net necrosis in its tubers. Heroic efforts are being made to "make the Green Mountain good," but even if it does regain its former position it should be remembered that for at least 5 years the new varieties saved the potato industry in relatively large sections of Aroostook County.

Warba, and later Red Warba, were distributed by the Minnesota Agricultural Experiment Station because of their earliness and high yielding ability. They are outstanding for these two characters and should be valuable for victory gardeners or growers who attempt to get new potatoes as early in the season as possible.

Golden was the first yellow-fleshed variety distributed in this country under the program. It was short-lived not because of its yellow flesh but because it had a short rest period. There is a demand for yellow-fleshed varieties in this country, especially since South America has begun to look to the United States for seed potatoes. The short rest period did not interfere with the keeping quality when the potatoes were kept in the storage house of Aroostook Farm, Maine, but when Golden was increased and attempts were made to market the potatoes they sprouted before they could all be sold to advantage.

Houma was selected in Lousiana because it gave a satisfactory performance in the Houma district of that state. It was found, however, to be very susceptible to early blight there, and although it still produces satisfactory yields other varieties have been given the prefer-

ence in that state. It had shown promise in Maine before it was sent to other states for test, and it is now grown to some extent in the northeastern section. In 1943 Maine, New Hampshire, New Jersey, New York, Pennsylvania, and Vermont produced a total of 203,380 bushels of certified seed of this variety. Vermont produced 29,355 bushels, which represented about one-sixth of all the certified seed grown in the state.

Earlaine is an early variety, producing high yields of smooth tubers under favorable conditions. It ranked first among the early varieties in the 1943 tests on Aroostook Farm, Maine, but it cannot compete with Irish Cobbler, Warba, or Red Warba when conditions are not so favorable; consequently, it has not increased in production.

Sebago was released not because it was perfect but because it had the best combination of characters available at the time. It produces high yields of tubers with satisfactory market and cooking qualities. Its vines are upright and more resistant to late blight than those of any of the commonly grown commercial varieties, although not nearly so resistant as some of the other seedlings. Its tubers are resistant to rots initiated by the late-blight fungus, one of the most valuable characters obtained so far, and it is more resistant to scab than Irish Cobbler or Green Mountain. Sebago is immune to mild mosaic in the field, and up to the present time its tubers have not developed net necrosis as the result of infection with the leaf-roll virus. Tests in the Hastings district of Florida have shown it to be resistant to brown rot, and trials in New York and Wisconsin indicate that it is resistant to yellow dwarf.

A mistake was made in choosing the name Earlaine 2. It is being confused with Earlaine. Earlaine 2 has nothing to recommend it but high yield. In this respect it is outstanding in various places.

Pontiac was released in Michigan, because it produced high yields on the muck soils of that state. It has shown promise in tests in the Hastings district of Florida and in districts of Wisconsin and Minnesota bordering on Lake Superior. In any district where a late, red-tuber high-yielding variety is required Pontiac should meet the requirements.

Mesaba was distributed in Minnesota and Iowa, because it is early and produces tubers of high market quality.

Sequoia was introduced in North Carolina because of its superior yields of tubers with high market and cooking qualities. Its resistance to injury by leafhoppers and fleabeetles is very much in its favor in the higher altitudes of North Carolina, Maryland, and other sections of

the country. A recent report from Connecticut stated that because of its vine resistance to diseases and insects it should be valuable in that state especially to growers who do not have good spray equipment. Although it was distributed to meet the needs of a rather restricted area, certified seed was produced in 11 states in 1943. The 5 leading states in the order of production of certified Sequoia are: Maine, North Carolina, New York, Maryland, and Tennessee.

Erie was released in Ohio where it competes successfully with the old standard varieties.

Pawnee was produced in Colorado. It was distributed because of satisfactory yields of high-quality potatoes and because it was better fitted to the farm management of growers who produced both potatoes and sugar beets. It is medium early. Favorable reports of it are coming in from other sections of the country.

Mohawk was put out in New York as a high-quality baking potato, but it will probably be increased for other reasons. It produces well in Maine. So far only a slight tendency to develop net necrosis in the tubers has been found, and if this resistance proves to be real the Mohawk will become another serious competitor of Green Mountain, which is very susceptible to this disease. A report from Connecticut states that because of the fine quality of the Mohawk it ought to be produced in that state for a special market.

Kasota was released jointly by Nebraska and Minnesota because of its tolerance to fusarium wilt, which is a destructive disease in that section of the country. Favorable reports of its behavior have come from Nebraska and Minnesota and from a few other sections of the country.

Potomac, the newest member of the group, was released in western Maryland. It outyields the Rurals in western Maryland and in West Virginia. The Rurals have been the standard late varieties in both of these states. The Potomac has two characters that give it superiority over the Sequoia; it produces somewhat smoother tubers, and they are more resistant to late blight rot. In the latter respect it is not equal to the Sebago, but both the Potomac and the Sequoia produce higher yields in that section than the Sebago. All things considered, the Potomac seems to be the best variety available for that section at present. Each of these varieties has been released to fill a special need, but none of them has reached the ultimate aim of the potato breeders. An inventory of the important characters that are available, many of which have been brought to light since the organization of the national potato-breeding program, would include the following:

1. Wide adaptation. Variation in time of maturity from very early to very late.

2. Desirable shape of tubers with the tendency to hold that shape under a wide range of environmental conditions.

3. Shallow eyes, making it easier for the grower to brush or wash the tubers before marketing them and causing less waste in preparing them for cooking.

4. High yielding ability.

5. High specific gravity with its correlated character of dryness of flesh, which is preferred by the majority of consumers in the United States.

6. Field immunity from mild mosaic.

7. Immunity from latent mosaic.

8. Resistance to veinbanding mosaic.

9. Resistance in the vines to the leaf-roll virus.

10. A high degree of resistance to net necrosis in the tubers, caused by current-season infection with the leaf-roll virus.

11. Resistance to yellow dwarf.

12. Resistance to or immunity from late blight in the vines.

13. Resistance to tuber rot initiated by the fungus that causes late blight.

14. Resistance to common scab.

15. Resistance to or tolerance of fusarium.

16. Immunity from potato wart.

17. Resistance to southern bacterial wilt or brown rot.

18. Resistance to leafhopper injury.

19. Resistance to flea beetle.

20. Resistance to psyllid yellows.

21. Resistance to injury caused by aphids.

These characters are not to be found in any one variety but are distributed among a relatively large number of varieties and seedlings, and it will take a long time to combine even a majority of them in a single variety. In other words, a variety that has wide adaptation, high yield, high market quality, superior cooking quality, and resistance to the numerous diseases which attack the potato will probably not be produced in the near future. Progress, however, is being made in the production of varieties with new combinations of characters, which a few years ago were thought to be improbable, if not impossible, to obtain. Varieties have been produced that combine earliness and good cooking quality with a high degree of blight resistance. Others have earliness and high market quality combined with scab resistance. One

is rather resistant to scab and moderately resistant to late blight. This variety produces high yields, and the cooking quality is satisfactory when it is grown in Maine. Its tubers are usually rough when they grow large, and the variety is too late for some of the sections in which scab is becoming a limiting factor in potato production. Nevertheless, it may become necessary to use scab-resistant varieties that are not wholly satisfactory until better ones can be produced. If not, potato production may be curtailed for a while in such sections as Menominee County, Michigan, parts of the Carbondale district in Colorado, and in some of the muck lands of Minnesota, Iowa, and Indiana. Under ordinary conditions this curtailment might do little harm, but under the present emergency the production of food is all-important, so one of these scab-resistant varieties, although it is not up to the standard in every particular, will be increased for a restricted but important area where, because of scab, it is almost impossible to grow U. S. No. 1 potatoes of susceptible varieties.

Some alarm has been expressed at the rapidly growing number of varieties that are being put into production, but that is inevitable. More than 30 state experiment stations are cooperating with one another and with the United States Department of Agriculture in the potato-breeding work. Each station is interested in the problems of the growers in its section. Additional new varieties will be produced, and they will be distributed as soon as there is a distinct need for them.

As the work progresses, however, it will be increasingly difficult to produce varieties superior to those already in production. When Katahdin was first released it surpassed many of the commercial varieties in yield, market quality, and disease resistance. Since then, many seedlings that have been equal or perhaps slightly superior to Katahdin have been discarded, since nothing is considered for distribution unless it is superior in at least one vital character to the standard varieties of a given section. It does not seem that the new varieties are hurting the potato industry. The yield in 1943 for the United States as a whole is reported to be a little more than 139 bushels per acre, which is a new record, and the total production was more than 460 million bushels,—also a record. In contrast with this the yield per acre for the United States in 1917, during the first World War, was approximately 100 bushels. In that year a record crop, for the time, of 442 million bushels was produced, but it required many more acres to produce it than to produce the much larger crop of 1943.

A direct comparison between the years 1943 and 1917 might lead to erroneous conclusions, however, since other factors, as well as the

new high-yielding disease-resistant varieties, were also involved. The growing conditions in the states that produce the major part of our crop were very favorable in 1943, and improved methods of soil management and disease control are more widely used today than 25 years ago.

More potatoes are grown from certified seed now than ever before, —a practice that has contributed greatly to the increase in the yield per acre. In this connection a word of caution should be given: Don't use poor seed of any variety, whether old or new. Poor seed is nearly certain to produce a poor crop, and the variety is often blamed when the blame should be placed on the quality of the seed.

INFLUENCE OF NITROGEN, PHOSPHORUS, POTASSIUM AND CALCIUM ON TUBER AND FOLIAGE WEIGHT OF POTATOES

R. L. Carolus

Virginia Truck Experiment Station, Norfolk, Va.

In order to establish more clearly the influence of some of the more important nutrients on the growth of white potatoes, and to determine how they should be balanced for maximum yields, a factorial experiment, involving three levels each of nitrogen, of phosphorus and potash, and two levels of calcium, was laid out in 1941 on a Sassafrass sandy loam soil located on the Eastern Shore of Virginia. The soil type was typical of the area but the site selected, with the exception of the pH value which was 5.0, was somewhat below the average of the better potato soils of the section in physical and chemical properties. The fertilizer treatments consisted of all combinations of 60, 120, and 180 pounds of N (nitrogen); 80, 160, and 240 pounds of P_2O_5, (Phosphoric Acid); 60, 120, and 180 pounds of K_2O (Potash), and 0 and 120 pounds of CaO (Calcium Oxide) to the acre or 54 treatments, as indicated in table 1. The nitrogen was derived as follows: from Sulfate of Ammonia, 50 per cent; from Uramon, 16.7 per cent; from Nitrate of Soda, 16.7 per cent; from Tankage, 16.6 per cent. The phosphate was derived from Triple Superphosphate for the purpose of partially eliminating the influence of Gypsum found in normal Superphosphate. Fifty per cent of the potash was derived from KCl (Potassium Chloride) and 50 per cent from K_2SO_4 (Potassium Sulphate) and the calcium was applied in the form of Gypsum. Each treatment was in triplicate and the plots consisted of three rows forty-five feet long.

The yields of both the 1941 and 1942 crops were severely reduced,

because of extremely dry weather during the growing season, and are not reported. Following the 1942 potato crop, sorghum as a green manure crop was planted. A total of 23 inches of rain fell from the 1st of July to the 1st of November which resulted in an extremely heavy growth of this crop. The sorghum was cut into the soil in early November, rye was seeded as a winter cover, the field was plowed in late February and the crop was planted early in March. Rainfall and temperature conditions during March, April and May were exceptionally favorable for the development of the potato plant. However, during June, the rainfall was less than 50 per cent of normal and temperatures were unseasonably high.

Results

An examination of the plots indicated that the foliage was progressively darker with increasing amounts of nitrogen and progressively lighter with increasing amounts of potash. The lightest colored plants were observed on plots fertilized with the lowest rate of nitrogen and highest rate of potash. Plants fertilized with the intermediate phosphate mixture were somewhat lighter than those receiving either more or less phosphate in the fertilizer. No general comparison could be made between plots that received calcium and those that received none.

The crop was dug late in June and both tubers and plants were weighed. The results are shown in table 1. Total yield varied 50 per cent from 90 bags to the acre in treatment No. 37 to 135 bags to the acre in treatments Nos. 15 and 18. Plant weight varied 100 per cent from 5400 pounds to the acre in treatment No. 1 to 10,800 pounds in treatment 54. A statistical analysis of the results, for both tuber and plant weight, indicated that there were highly significant differences attributable to nitrogen, phosphorus and potassium fertilization. As indicated by the interaction variances the efficiency of no nutrient was significantly influenced by the level of any other nutrient or nutrients.

Amounts of nitrogen higher than 60 pounds to the acre significantly decreased the yield of tubers. Plant weight was significantly increased 2500 pounds to the acre when the nitrogen application was increased from 60 to 120 pounds. An additional increase in the nitrogen application from 120 to 180 pounds to the acre did not significantly increase plant weight but highly significantly decreased tuber yield by 12 bags to the acre. The highest rate of application of phosphorus 240 pounds of P_2O_5 to the acre significantly increased the yield of tubers and the plant weight over the intermediate rate of 160 pounds of P_2O_5 to the acre.

Discussion

The results obtained, so far as tuber yields are concerned, are not consistent with the fertilizer practices in the area. Some plausible ex-

Table 1.—*Influence of nitrogen, phosphorus, potassium and calcium on tuber and plant weight of white potatoes.*
(Averages of three plots)

Treatment No.	Nutrients Applied Lbs. to the Acre			Total Tubers Bags to the Acre		Plants. Lbs. to the Acre (00 omitted)	
	N	P_2O_5	K_2O	No CaO	120 CaO	No CaO	120 CaO
1, 2	60	80	60	111	109	54	52
3, 4	"	"	120	114	115	61	54
5, 6	"	"	180	106	112	56	54
Ave.	60	80		110.3	112.0	57.0	53.0
7, 8	60	160	60	119	117	55	56
9, 10	"	"	120	123	128	59	63
11, 12	"	"	180	134	128	63	60
Ave.	60	160		125.3	124.3	59.0	59.7
13, 14	60	240	60	126	125	60	62
15, 16	"	"	120	135	128	65	61
17, 18	"	"	180	127	135	66	76
Ave.	60	240		129.3	129.3	63.7	66.3
Ave.	60			121.7	121.9	59.9	59.8
19, 20	120	80	60	98	106	72	76
21, 22	"	"	120	99	105	69	73
23, 24	"	"	180	104	105	81	79
Ave.	120	80		100.3	105.3	74.0	76.0
25, 26	120	160	60	111	113	78	80
27, 28	"	"	120	117	112	88	79
29, 30	"	"	180	118	120	84	88
Ave.	120	160		115.3	115.0	83.3	82.3
31, 32	120	240	60	122	119	84	90
33, 34	"	"	120	121	120	99	93
35, 36	"	"	180	134	131	103	103
Ave.	120	240		125.7	123.3	95.3	95.3
Ave.	120			113.8	114.5	84.3	84.5
37, 38	180	80	60	90	95	73	70
39, 40	"	"	120	91	91	73	72
41, 42	"	"	180	87	98	74	80
Ave.	180	80		89.3	94.7	73.3	74.0
43, 44	180	160	60	107	99	93	88
45, 46	"	"	120	103	98	91	89
47, 48	"	"	180	106	117	100	98
Ave.	180	160		105.3	104.7	94.7	91.7
49, 50	180	240	60	102	110	99	100
51, 52	"	"	120	105	109	99	102
53, 54	"	"	180	112	123	100	108
Ave.	180	240		106.3	114.0	99.3	103.3
Ave.	180			100.3	104.5	89.1	89.7
Ave. CaO				111.9	113.6	77.7	78.0

planations, at least for the low nitrogen requirement, should be offered. The plots that had received only 60 pounds of nitrogen to the acre for three successive years produced the largest tuber yield. Inasmuch as the yields during the first two years of the experiment were exceedingly poor the possibility of an accumulation of residual nitrogen should be considered as a possible explanation. Any accumulation of residual nitrogen was effectively prevented from being leached by the green manure crop of sorghum, which because of ideal growing conditions probably utilized all of the residual nitrogen and produced a large volume of organic matter.

An explanation for the reduced yields with amounts of nitrogen greater than 60 pounds to the acre cannot be attributed to excessive plant growth. The yield was reduced by 7 bags to the acre when the fertilizer was increased from 60 to 120 pounds with an increase of 2500 pounds in plant weight, but was reduced 12 additional bags when the fertilizer was increased from 120 to 180 with an increase of only 500 additional pounds in plant weight. It would appear that excessive amounts of nitrogen interfere in some way with normal metabolic processes in the potato plant.

Although unfavorable growing conditions may result in an accumulation of residual nitrogen that can be held in the soil against leaching, by growing green manure crops, apparently phosphatic materials are not retained in a form available to the plants on soils as acid as pH 5.0. On plots receiving 240 pounds of P_2O_5 to the acre, not only were the yields significantly greater than with a lower rate of phosphate fertilization but the plant growth was also significantly higher than that produced at a lower rate of phosphate fertilization. Plant growth is not necessarily associated with either a high or a low tuber yield as the results with different levels of nitrogen and phosphate fertilizer clearly show. Responses to potash were not so striking as those of nitrogen or phosphate and do not allow a satisfactory interpretation. The lack of response to calcium in the fertilizer, indicates that little of the value of superphosphate on potatoes can be attributed to its gypsum content. High analysis phosphatic materials should be suitable for use in potato fertilizers even on acid soils.

Conclusions

Following dry seasons in which much of the applied nitrogen is not utilized by the plant but prevented from leaching by green manure cropping, a reduction in the amount of nitrogen applied for potatoes is not only justifiable but highly desirable. On acid soils large quantities

of phosphate in potato fertilizers are apparently necessary, regardless of previous weather conditions, until the phosphate-fixing capacity of the soil is adequately satisfied. Tuber yields are not necessarily correlated with plant growth, as high tuber yields were produced on plots with both low and high plant weights and low tuber yields were also produced on plots with both low and high plant weights. In view of the above results a 5-10-5 analysis is probably at least as well suited to most soils on the Eastern Shore of Virginia as the 6-8-6 analysis and high analysis phosphatic materials may suitably be used in its formulation.

SECTIONAL NOTES

CALIFORNIA

It looks like the Shafter Potato Deal will end up in a blaze of glory.

The deal should be over in a week and in accordance with the present figures, the total shipments, rail and truck combined, will run close to 30,000 cars from an acreage of 51,000.

The price has held very closely to the ceiling throughout the period for U. S. No. 1 potatoes. U. S. No. 2 and egg size were in rather poor demand during the early part of the deal, but recently the demand has been improving very greatly for the cheaper grades and the range of prices, in general, advanced consistently toward the end of the deal.

The next California Potato Deal will be the Stockton Deal, beginning about the 15th of July, which will be shipping a similar type of U. S. No. 1 Washed Long White Potato. The acreage in Stockton is very much smaller than the acreage in Kern County, namely approximately 11,000 and the potatoes will move gradually, not more than 50-60 cars per day.

A large percentage of these potatoes will customarily go to California Markets, also Army, Navy and Lend-Lease requirements.

The growing season in Stockton has been very favorable as it has been unusually cool throughout June which makes for a good even growth.

At this moment, potatoes are without a ceiling. Some of the operators hardly know what to do; which shows you can get used to anything—even a Potato Ceiling. (July 5)—ERNEST MARX.

COLORADO

Our season, as far as potatoes are concerned, still continues late. Shipments from the earlier districts will not begin until the 15th of July, —which is from two weeks to a month late.

Plantings for the late crop are not yet altogether complete, and have been considerably delayed by rains. The weather, in general, throughout the state, has been cool,—with local showers, making a very wide variation in moisture conditions. Prospects, however, still appear good for a psyllid epidemic equal to that of 1938 or even as severe as that of 1931. Symptoms of psyllid yellows are already quite advanced in some of the early plantings, and the insects are abundant on volunteer plants and cull piles.

Weather conditions have also been excellent for late blight in those areas of the state where this disease occurs. (July 10)—C. H. METZGER.

IDAHO

Idaho potato growers have just completed one of the most adverse planting seasons in several years. Continued rains have delayed plantings for a period of three weeks in some areas. Fields on which planting was started about the 20th of May, were, in some cases, not completed for three weeks. Cold, wet weather has resulted in the decaying of some seed pieces, and in rather heavy attacks of Rhizoctonia. In some instances, cut seed has probably suffered some injury from being held too long during the rainy season. The growing season will be very short if frosts come early in the fall.

There has been a slight increase, however, on the acreage where sugar beet and bean fields have been discarded because of weeds or poor stands, but even this will not affect the total acreage very materially. From observations made throughout the potato-growing sections of the state, Idaho will probably plant between 25,000 to 30,000 acres less than the 197,000 planted in 1943. The number of applications for certification of seed fields has increased 50 per cent, compared with last year. No great interest is being shown in the War Approved Seed program, with only a few applications having been sent in to date. Several new areas are attempting certified seed production for the first time. (July 7)—EUGENE W. WHITMAN.

INDIANA

The drought and hot weather combined, have caused some concern with the potato growers during the past 15 or 20 days,—especially in central and northern Indiana. Our early crop is being harvested in the southern part of the state, the quality is good, and the yields are also above average. The demand for potatoes is only fair. This is per-

haps due to the high retail price to a lot of the consumers who do not grow any of their own potatoes and consequently are turning to other vegetables.

Our late-maturing potatoes look very good, but we still have a job fighting the pests—particularly the leafhopper which is very serious throughout all sections of Indiana. (July 6)—W. B. WARD.

KENTUCKY

Because of rain and unfavorable conditions, the planting of the first crop of Irish Cobbler potatoes was delayed an average of three weeks last spring. Normally our crop is planted by the middle of March. This year the planting was delayed until nearly the middle of April. About 4,000 acres were planted in Jefferson County. It is estimated that nearly 90 per cent of the seed used was northern grown certified stock,—the remainder home grown. The growth of the crop appeared good until the extremely high temperatures and abnormally dry weather occurred in late May. Yields have been materially reduced, estimated to be less than one-half normal. The quality of the crop is poor; less than one-half of the potatoes will grade out U. S. No. 1. Harvesting is just beginning at this date, however, and all our growers are greatly discouraged with the prospects. Normally, about one-half of the crop moves by rail, the remainder by truck or into local consumption. The market conditions being uncertain now makes it impossible to estimate the movement of this year's crop. The older, experienced potato men in the County state that generally speaking, the crop is the poorest that has been grown in this section for the past twenty-five years,—from the standpoint of both acreage and production. (July 14)—S. W. ANDERSON.

MINNESOTA

The estimated acreage of potatoes planted in Minnesota this year is approximately 224,000 compared with 243,000 acres planted in 1943. Certain areas were under water most of the planting season which will mean a considerable decrease compared with potatoes harvested in 1943. The peat areas particularly suffered in this respect.

Although some delay in planting was experienced in the early or sandland area, growing conditions have been good, with an abundance of moisture, and some potatoes are just about ready for harvesting.

In the Red River Valley, particularly in the northern counties, most of the crop was planted on time, but in the southern part, planting was

interrupted time and again by heavy rains with the result that planting has just been completed in some fields. This delayed planting has held up certification applications, but at the present time they are all in and the inspectors have been in the field since the 1st of July.

More than 35,000 acres are being inspected for certification as compared with 22,348 acres in 1943. In order to avoid confusion such as developed with reference to the War Approved Seed Potato program last year, we have only accepted applications for certification. All growers making application have been notified that any field of potatoes which is rejected, but which still meets the requirements for War Approved Seed Potatoes, will be classified as such.

The problem of an adequate inspection force loomed rather large earlier in the season because of the uncertainties of the draft status of some of our inspectors, but we have been fortunate enough to retain most of our trained men. For a time we thought we might not have a large enough force to inspect properly the increased number of fields and the additional acreage on which application for inspection was made. (July 10)—A. J. TOLAAS.

NEBRASKA

The late crop of Nebraska potatoes has finally been planted. In our memory, this is the most erratic season for planting, with regard to delays from storms, and generally late planting.

The early crop of both central and western Nebraska is usually planted during the last week of March and the first week of April. This year, about three days of planting took place before the extensive and destructive rainfall began. In most cases, the next plantings were three to four weeks later. Harvesting in that area has begun, and as a result will extend over a long period.

The late crop was being planted the first week of June, and this crop also ran into difficulties because of excessive rainfall. In most cases, there was a delay that varied from a week to ten days. Even after this time, there were occasional rains and some severe hail storms. The hails resulted in knocking out other crops, especially beans and beets under irrigation, which were subsequently replanted to potatoes. The result was that potatoes were still being planted on the 10th of July.

Favorable growing conditions have obtained, and all plantings are making good progress, so that the delay may not be of serious consequence. In view of the fact that we have had extremely early frosts in the past three years, the most critical feature will be our climatic conditions in the fall.

There has been little interest in future contracting of both table and seed stock. In the case of certified seed, these have been at ceiling prices,—when they are established. Most table stock contracts have been based on prices at time of harvest.

The Commercial crop is somewhat reduced, compared with last year, although our certified crop shows an increase. Since all records are not available, it is impossible to give the exact acreage at this time. (July 17)—MARX KOEHNKE.

NEW JERSEY

The potato crop in New Jersey has been seriously damaged by the long period of drought and high temperatures which have prevailed since the 20th of June. Many fields of Irish Cobblers and Chippewas have matured prematurely, and as a result, the yields will be greatly reduced. Katahdins, which make up approximately 50 per cent of the acreage, have also been extensively damaged, and therefore the yields will not equal those of last year. Some growers estimate that the drought this season has reduced yields as much as 50 per cent.

Aphids are severe in some areas and some damage is prevalent in our late varieties. Harvesting of Cobblers is now in operation in some sections,—with only light yields being reported. General harvesting is not expected to take place before the 24th of July. We experienced light showers in scattered areas on the 16th, but these were of little value to the potato crop. (July 17)—J. C. CAMPBELL.

NEW YORK

Ideal seed-bed conditions in May and, in general, ample rainfall during June resulted in a favorable start for the potato crop in New York State this year. However, the high rainfall in June naturally resulted in shallow root systems which would not well withstand the drought which generally prevailed over the entire state during the first ten days of July. With the exception of Long Island, most of the potato sections of New York received some rain between the 10th and 12th of July. Apparently the crop has not suffered seriously for lack of rain,—except on Long Island. The excess rainfall in June resulted in the initiation of late blight in many fields throughout the state. Late blight has been reported in every important potato section, although in very limited areas, and even at present it is not damaging. Nevertheless, the disease is sufficiently well initiated that it may develop to serious proportions depending upon the amount of rainfall from now on. Larger

emphasis is being placed on the organized custom spray rings of which there are more than forty in the state this year. Because of the difficulty of procuring good spraying equipment in these times, these custom spray rings are of immeasurable value to the potato industry at this time.

Long Island has suffered one of the worst droughts in many years. The crop started out well, but unless rain has occurred since the 12th of July, the crop is now suffering seriously. Aphis injury is increasing rapidly and fields not provided with irrigated water will be injured beyond recovery. Although the Long Island crop was already suffering from the drought by the 1st of July, not a drop of rain occurred in Suffolk County during the entire week from the 5th to the 11th of July.

Because of transportation difficulties, no state-wide or regional potato meetings have been scheduled for this summer. (July 15)—E. V. HARDENBURG.

OHIO

The early potato crop will be somewhat reduced because of the extremely hot, dry weather. May almost broke the record for heat, as is shown by the fact that it was recorded as the second warmest May in the history of the Weather Bureau. Very little rain fell during June and in some sections of southern Ohio none has fallen for the past month. All areas are now suffering from the lack of moisture. Unless there is some rain in the near future, the early crop will probably be cut at least one-half.

The late potatoes are not suffering so much as the early ones, because few of the late crops have set tubers.

There has been little interest shown in Ohio so far this year in the War Approved Seed program. Seed was plentiful last year and a considerable quantity of unsold certified seed was sent to the sugar factory to be made into alcohol. Very few potatoes have been planted in Victory Gardens this year. (July 10)—E. B. TUSSING.

VERMONT

Although no definite checkup of general potato acreage has been made in Vermont, indications point to a somewhat lowered total. Any decrease, however, will be in the smaller plantings, including Victory Gardens. Most of the large commercial and seed growers have planted about the same acreage as they planted last year. The few decreases in individual acreage are probably balanced by increases in others and by a few newcomers in commercial growing.

The acreage entered for certification is somewhat reduced from last year's figure, but is well above the average for several years just preceding 1943. About 650 acres will be inspected. There appears to be a marked tendency toward larger acreages among fewer growers. The practice of growing an acre or two for certification as a side line to dairy farming is apparently on the decline.

Green Mountains still predominate among varieties, though the trend toward Katahdins and others free from net necrosis continues in evidence.

It is too early to give figures on field inspection, but among the 70 samples submitted for the central test plot, only three had readings definitely disqualifying the lots they represent, though several others were on the danger line. Leaf roll was the controlling factor in all cases. (July 11)—HAROLD L. BAILEY.

VIRGINIA

The early potato deal of Eastern Virginia has been a source of worry to the growers from the date of planting through the harvesting season. During March, when potatoes should have been planted, the rainfall was excessive. About one-half the acreage was planted two to four weeks later than usual and much of it was planted when the soil was too wet. About the middle of April the rain ceased, and a long period of drought, the worse in the history of this area, set in. Combined rainfall for the months of May and June at the Norfolk Weather Bureau was the lowest in history by a rather large margin. In the Norfolk area practically no rain has fallen to date,—the 14th of July. On the Eastern Shore several showers during the latter part of June were of considerable value to the late-planted acreage. Yields have been exceedingly variable, even within short distances,—depending on soil type and the condition of the soil when the potatoes were planted. Soils low in organic matter and those that were planted when wet became very hard during the drought and produced very low yields. In some cases the yield was less than 30 bags of U. S. No. 1's per acre. Some few growers obtained fairly good yields considering the shortage of rainfall, but in most cases these yields did not exceed 80 sacks of U. S. No. 1's per acre. A rather limited acreage which was irrigated, gave excellent yields.

The carrying quality on the whole has been above the average with very little rot reported, but the size has been slightly too small in general to suit the trade, especially since there was an abundance of large California whites on the market. Practically all size B potatoes were pur-

chased by the W. P. A., since there was no demand for size B on the market. The Federal purchase of the size B grade was of great value in maintaining a fair market for the U. S. No. 1 and U. S. No. 1A grades which have been ceiling at a price varying from $3.00 to $3.20 per 100-pound sack.

Our movement is now past its peak, but heavy movement will probably continue from the Eastern Shore until the week ending the 22d of July. Because of the low yields the labor situation has not been too serious, and the limited amount of labor has probably been beneficial in preventing too heavy movement on any one day from the Eastern Shore section. (July 14)—H. H. Zimmerley.

Washigton

Conditions, in general, have been quite favorable for our seed potato crop. Prospects at the present time appear to be about normal, with a little more than 50 per cent increase in the acreage of seed potatoes upon which certification has been requested. The commercial potato acreage is down approximately 25 per cent below last year's production, with apparently less disease due to the use of a larger percentage of certified seed. This will probably increase the production under normal conditions beyond the difference in the acreage planted.

Although we had a very dry early spring, recent rains and continued moderate temperatures have contributed to a fine growth of potato fields generally. (July 8)—Chas. D. Gaines.

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SUITABILITY FOR DEHYDRATION IN WHITE POTATOES AS DETERMINED BY THE FACTORS OF VARIETY AND PLACE OF PRODUCTION. I.

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Introduction

Dehydrating or drying of potatoes is not a new process. It was practiced by the natives of South America when the Spaniards arrived in that country to search for gold. In a report on the conquest of Peru it is said that in 1530 De Cortez found potatoes growing at very high altitudes of 10,000 to 11,000 feet above sea level. These were harvested and dried by very primitive methods, after which the dried product was loaded on llamas and transported to the lower valleys to be used as winter food. This dried product, which they called "chuno" or "chunyo" would keep for long periods. It is said the Indians of Peru prepare their chuno in much the same manner today.

In the United States, Canada, and England the dehydration of potatoes is primarily a war industry. In some of the countries of Europe, in Germany in particular, the drying of potatoes for human food or for feeding stock has been practiced for a long time.

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Dried potatoes have several advantages over fresh tubers. In the first place they weigh much less. A ton of raw potatoes will make about 400 pounds of the dried product. There is little, if any, danger of freezing or overheating. If properly packed and stored they will keep for much longer periods than the fresh potatoes. These are extremely important advantages, especially in time of war when food has to be shipped long distances overseas.

As soon as the United States entered the present war there was a big demand from the military people for dehydrated potatoes. To meet this demand a number of problems had to be solved. Factories had to be built, equipment installed, and techniques of handling and processing had to be perfected. The problems of development of dehydrating equipment capable of efficiently and economically handling very large quantities of material have been solved by concerted attack, and the technology of preparation, drying, storing, and packing the product in such ways as to preserve nutritive value and delay deterioration has also been developed and standardized.

Little information was available with respect to the suitability of various varieties for drying purposes. The experimental studies that had been reported were made upon a few varieties, sometimes upon a single variety, readily obtainable in a locality, and differences in techniques and previous handling of material made comparisons between the results of different workers difficult if not impossible.

About 3,000,000 acres are annually planted to potatoes in the United States, and approximately 95 per cent of this acreage is devoted to 10 varieties. These 10 varieties differ greatly in their adaptability, a few being grown in all the important potato-growing sections, whereas others are confined to a particular district or to a few states. In addition, a number of new varieties are meeting with such acceptance that the area devoted to them is rapidly increasing at the expense of the older varieties. All these varieties show rather wide variation in cooking quality over the range in which they are grown, for which reason a variety ranked as best in one part of its range is often inferior to others in another district.

The present work reports a study of the comparative suitability for dehydration purposes of all the more important varieties of potatoes grown commercially in the late or main-crop potato-producing areas of the United States. Some of the more promising recent introductions were tested also. Material of each variety was procured from a number of districts in which it is important, and was so handled that the

results were rigidly comparable throughout. The results serve in some degree as an inventory of the varietal material most suitable for dehydration and as a directory of the producing areas in which different varieties may be expected to give the most satisfactory dehydrated product.

Materials and Methods

Through arrangements with co-operators of the national potato-breeding project, material representing all the more important varieties of the various northern districts was shipped to Beltsville, Maryland, from 9 stations located in 7 states. The material from Presque Isle, Maine, included 15 varieties; State College, Pennsylvania, 11; Aberdeen, Idaho, 8; Puyallup, Washington, 5; Greeley, Colorado, 4; Lake City, Michigan, 5; Rogers City, Michigan, 6; and Ithaca and Elba, New York, 4 each. In addition to this material certain varieties grown at Aroostook Farm, Presque Isle, Maine, in an experiment conducted to determine the effects of various levels of fertilizer application and spacing in the row upon yield and quality were included in the drying experiment in order to get information upon any influence that these treatments might have upon behavior in the drying and final quality of the dried product.

The varietal material from the various states and from the fertilizer tests was handled throughout in precisely the same manner. The tubers were first examined for appearance and market grade, and their specific gravity was determined. They were weighed, pared by immersion with agitation in 10 to 12 per cent lye solution at approximately 185° F. for 8 to 10 minutes, washed free from lye, drained, and weighed to determine peeling loss. Afterwards they were trimmed by hand, the trimmings being collected and weighed. They were sliced into Julienne strips three-eighths by three-eighths inch, placed in cold 1½ per cent salt solution, agitated to separate pieces and to moisten all surfaces, removed, placed in a steam-box, pre-cooked in strongly flowing steam for 5 minutes, and immediately placed in the dehydrator. As the various lots of material reached a 7 to 8 per cent moisture content they were removed from the drier, weighed, bagged separately in heavy cloth bags, and stored in a warm dry room. Under these conditions their weights remained practically constant until the drying of all lots was completed. The dried product was stored in various ways, some in air-tight cans. Duplicate lots were left in the cloth bags and stored at different temperatures. Samples were

tested, from time to time, to determine the rate of deterioration of the product stored under the various conditions.

In preparing the dried stock for eating, samples were weighed out and placed in a container, and water was added. They were allowed to soak or "refresh" over night. No salt or other seasoning was added, as the presence of salt made it difficult or impossible to detect small differences in taste. At the end of the refreshing period the material was boiled for 30 minutes. The samples were then drained, put through a ricer, inspected, and tasted by a number of people.

The factors considered in comparing the various samples were color, flavor, and texture. These were made the basis of the final score on culinary desirability. The scores were grouped in four classes: fair, good, very good, and excellent.

Results

The data on the cooking quality of the dehydrated products of 19 varieties of potatoes grown in various environments are given in table 1. It is apparent that varieties differ from each other when grown under similar conditions and that the samples of the same variety differ if grown under different conditions. The varieties grown in Maine were rather ocnsistent in quality. Of the 14 from that state, 1 was good; 3, very good; and 10, excellent. There was a wider difference in the varieties grown in Pennsylvania. Of the 11 varieties received from that state, 1, was fair; 2, good; 4, very good; and 3, excellent. Katahdin was grown in each of the 9 locations. Its quality varied from fair to excellent (Table 1). Some of the other varieties did not show so wide variation as Katahdin, but they were not so fully represented by samples from all parts of their range of adaptation.

It is clear then that there is no "best" variety of potato for dehydration, or no "best" district from which to obtain potatoes for this purpose. For all varieties it is evident that the final quality and desirability of the dehydrated product are dependent on the adaptation to the conditions under which the varieties are grown. All the varieties, with one exception, made a product scoring "excellent" in one or more locations, indicating favorable adaptation to conditions in such places. It should be noted that the lowest rating given to any sample was fair, showing that they were all acceptable as food products. Each of the districts, however, had a number of varieties that scored excellent, or very good, and these might be preferred above the others in that district.

TABLE I.—*Cooking quality scores of dehydrated products of* 19 *varieties of potatoes.*

Varieties	Places where potatoes were grown and classes[1] of cooking quality								
	Maine	Pennsyl-vania	Idaho	Rogers City, Mich.	Lake City Mich.	Colo.	Wash.	Ithaca, N. Y.	Elba, N. Y.
	Class	Class	Class	Class	Class	Class	Class	Class	Class
Katahdin	3	2	3	3	3	4	1	2	3
Sebago	4	3	1	3	..	..	3	..	..
Irish Cobbler	3	2	2	2	3	..	..	..	..
Chippewa	4	3	3	3	3	..	..	3	2
Green Mountain	4	4	..	3	..	..	..	4	4
Sequoia	4	3	..	..	..	..	2	..	..
Houma	4	3	2	..	..	..	..	..	..
Warba	4	2	..	..	..	..	..	..	..
Red Warba	4	..	..	..	..	..	..	..	..
Earlaine 2	2	1	..	..	..	..	..	..	..
Pontiac	4	..	2	2	..	..	2	..	..
Triumph	4	..	3	..	..	..	..	..	..
White Rose	3	..	..	..	..	4	2	..	..
Russet Rural	..	4	..	3	4	..	..	..	..
Rural New Yorker	..	4	..	..	..	..	..	..	..
Russet Burbank	..	..	4	..	..	3	3	..	..
Pawnee	..	..	..	..	..	..	..	..	..
Mohawk	4	..	..	..	..	3	..	..	..
Pioneer Rural	..	..	..	..	..	..	..	4	4

[1]Classes of cooking quality:
1 = fair
2 = good
3 = very good
4 = excellent

Two varieties, Green Mountain and Sequoia, were grown at Aroostook Farm, Presque Isle, Maine, with five rates of application of double-strength (8-16-14) fertilizer, namely, 500, 750, 1,000, 1,250, and 1,500 pounds per acre. Lots of potatoes from each of the plots in the test were shipped to Beltsville, Maryland, dehydrated, and scored in precisely the same way as the material used in the varietal and place comparisons.

The differences in the cooking quality of the dried products as affected by fertilizer application were not statistically significant but were very consistent and similar in the two varieties. All samples were rated good to excellent. The lots receiving 1,500 pounds per acre were placed in the group rated good. The plots receiving 500 and 750 pounds were very good, and those receiving 1,000 pounds were rated excellent. The trend of the changes in the two varieties was identical, and if 1 year's data can be relied upon, it might indicate that 1,000 pounds of a double-strength fertilizer is really the upper limit that can be employed with potatoes without lowering the quality of the dehydrated product that is made from them.

What has been found in other cooking tests with potatoes was found in the dehydration tests; that is, the specific gravity, which is a relative measure of the dry matter in the tuber and closely related to the starch content, is correlated with cooking quality. The relationship is not absolute, however, and although high specific gravity may not always give high cooking quality, it is quite certain that low specific gravity cannot be expected to give superior quality in the finished product. All other things being equal, high specific gravity of tubers is more to be relied upon in purchasing tubers for dehydration purposes than the name of variety or the place of production.

SUITABILITY FOR DEHYDRATION IN WHITE POTATOES AS DETERMINED BY THE FACTORS OF VARIETY, PLACE OF PRODUCTION, AND STAGE OF MATURITY. II

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Introduction

In an earlier paper (1) results were reported of a study of the suitability for dehydration of late or main-crop potatoes. Each of the 19 varieties tested was found capable of producing a dehydrated product of high quality when grown under conditions to which it was well adapted. If, however, the variety was grown under each series of conditions to which it was progressively less well adapted, the quality of the dried product became progressively poorer. There was a consistent correlation between the specific gravity of the fresh entire tubers and the quality of the dried product. Raw stock of high specific gravity gave larger yields of dry product with a more desirable texture or consistency (dryness or mealiness) when refreshed and cooked than stock of lower specific gravity. Color and flavor varied independently of specific gravity so that high specific gravity did not always determine high quality of product, but very few lots of potatoes of low specific gravity yielded products of highest excellence. These results are in general accordance with the work of Clark, Lombard, and Whiteman (2) who found a high positive correlation between specific gravity and the dryness and mealiness considered desirable in potatoes.

Purpose and Scope of the Present Work

The present paper reports the results of a study of the suitability for dehydration of the early or spring potatoes from the more important southern districts and from California. In order that the results might be directly comparable with those obtained from the late or main-crop potatoes the methods and technique were identical with those employed in that work. This report, consequently, completes a survey

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with respect to suitability for dehydration and quality of dehydrated product of potatoes from all the more important potato-producing districts of the United States.

Source of Material

The potato samples were obtained through collaborators in the national potato-breeding project from Hastings, Fla., Weslaco, Texas, Baton Rouge, La., Charleston, S. C., Olney, Va., Pocomoke City, Md., Shafter, Calif., Beltsville, Md., and New Brunswick, N. J. Each collaborator supplied the varieties that are most generally grown in his particular district with the result that nine varieties were represented in the material.

Various lots were harvested at the time that the commercial crop in the district was being dug for market. In a few cases two sets of samples were secured, one dug at the usual commercial harvest, the other 10 days to 2 weeks later after the tops had about dried up. A comparison between the products of the earlier and later samples affords an indication of the degree to which stage of maturity affects the quality of the product. All potatoes were shipped by express to Beltsville, Maryland, immediately after digging and were dehydrated within 2 or 3 days after their receipt. As the dates of harvest for the various stations ranged from the 20th of May for Texas to the 25th of August for New Jersey, the work was intermittent, but all lots were handled in identical fashion throughout. Any given sample of a variety consisted of at least 100 pounds of potatoes, and a number of samples were larger.

Condition of the Raw Stock

As the various shipments were received diseased or decaying tubers were removed and notes were made on the size and condition of the sample. As a rule, the samples consisted of sound potatoes, varying rather widely in size. A portion of each sample was sorted for size into two or three groups, and specific gravity determinations were made upon a number of potatoes of each group. In any sample there was a relationship between the size of tubers and the specific gravity,—the larger tubers having on the average the higher specific gravity.

The immature condition of all varieties received from Texas, Florida, Louisiana and of the early-dug material from South Carolina, Virginia, and Maryland was apparent. This was indicated by the relatively small size of the tubers and the loosening and rubbing off of the skins. The size of tuber and the amount of skinning varied

somewhat with variety and place of growth, but it is conservative to state that 70 to 75 per cent of all potatoes of all varieties from the above states were under 2½ inches in diameter, with a considerable number ranging down to 1¾ inches, and that 15 to 20 per cent of their peels had been loosened and rubbed off in shipment.

Specific Gravity

Practically all samples from the first or commercial harvest, regardless of variety or place of growth, were very low in specific gravity (Table 1). Five samples were harvested at the usual commercial digging time, and samples from the same plots were dug after the plants had matured. In every case the specific gravities of the second series was higher than those of the corresponding samples of the first. In 22 of the commercially-harvested lots and 2 of the delayed digging lots the specific gravities ranged from a maximum of 1.062 to a minimum of 1.035, with the majority falling in the range 1.040 to 1.055. In the remaining 6 samples the range was from 1.064 to 1.075. That these values are very low as compared with those of fall-crop potatoes grown in northern producing districts is evident from comparison with results reported on 60 samples representing 20 varieties grown in seven Northern and Western States (1). In 34 of these fall-crop samples the specific gravities ranged from 1.084 to 1.104; in 18, from 1.070 to 1.083; and in 8, from 1.062 to 1.069. That is, the highest specific gravities found in the Southern-grown potatoes are in the lower limits of the range found in the Northern-grown material, and the great majority of samples are decidedly lower in specific gravity than any found in the Northern stock. As specific gravity is directly related to total solids and starch content, which determine yield of dry product and are highly significant in determining its quality, this is a fact of outstanding importance.

Starch Content

The percentages of starch are low for all the early-crop samples and extremely low for a few of them. In fact, the average percentage for all varieties is about 55 per cent, or a little over one-half, of the starch content of the same varieties grown at Presque Isle, Maine, in 1943.

Losses in Preparation

The losses in preparation due to peeling and trimming were highly variable, not only from variety to variety but within the samples of a variety from different districts. Some of the factors involved were

TABLE 1. *Specific gravity, starch content, loss in preparation, and yield and quality of dry product of the early or spring potatoes from the more important Southern districts and from California.*

Variety	Date Dehydrated	Source	Mean Specific Gravity	Starch Content	Loss in Preparation	Dry Weight	Quality Score[1]	
							Regular	Sulfured
				Per cent	Per cent	Per cent		
Chippewa	May 25	Texas	1.056	8.4	22.6	14.2	68	72
Do	June 4	Louisiana	1.049	6.7	23.9	13.3	73	77
Do	June 5	South Carolina I[2]	1.052	7.4	23.6	12.4	69	73
Do	June 18	do II	1.059	9.2	21.3	17.0	78	82
Do	August 31	New Jersey	1.053	7.7	16.8	15.1	78	81
Irish Cobbler	June 1	Florida	1.052	7.4	22.7	15.1	75	77
Do	June 5	South Carolina I	1.058	8.9	21.6	15.5	70	75
Do	June 18	do II	1.075	12.9	22.0	18.2	87	90
Do	June 29	Virginia I	1.062	10.0	22.7	16.8	68	74
Do	July 12	do II	1.064	10.5	21.8	17.4	80	84
Do	July 31	Maryland I	1.047	6.2	21.4	14.6	76	83
Do	August 12	do II	1.055	8.2	21.4	15.5	85	89
Do	August 31	New Jersey	1.056	8.4	20.1	17.0	72	85
Katahdin	June 1	Florida	1.057	8.7	21.0	16.3	70	78
Do	June 3	Louisiana	1.043	5.2	15.9	15.2	63	75
Do	June 5	South Carolina I	1.047	6.2	22.0	12.8	75	75
Do	June 18	do II	1.069	11.6	21.9	17.7	83	85
Do	July 27	Maryland I	1.035	3.2	20.4	12.2	76	80
Do	August 31	New Jersey	1.056	8.4	13.8	15.9	82	88
Sebago	May 25	Texas	1.066	11.0	16.2	15.3	80	..
Do	June 2	Florida	1.050	6.9	23.5	15.2	80	83
Do	June 3	Louisiana	1.049	6.7	18.3	15.3	68	76
Triumph	May 25	Texas	1.052	7.4	27.5	10.9	65	78
Do	June 1	Florida	1.061	9.7	27.1	13.3	75	80
Do	June 4	Louisiana	1.046	5.9	21.2	14.0	59	65
Sequoia	June 18	South Carolina II	1.051	7.2	23.5	15.6	75	80
White Rose	May 25	Texas	1.051	7.2	27.3	11.2	83	..
Do	July 26	California	1.075	12.9	16.4	21.2	89	90
Pontiac	June 18	South Carolina II	1.065	10.7	23.0	15.6	73	80
Red Warba	July 27	Maryland I	1.054	7.9	18.4	15.2	88	85

[1]The scores for quality expressed in descriptive terms are as follows:

Below 60	= Poor	80-89	= Very good
60-69	= Fair or acceptable	90-100	= Excellent
70-79	= Good		

[2]The Roman numerals I and II denote commercial-harvest and delayed-harvest material from the same plots.

differences in size of potatoes, in amount of skinning that had occurred in harvesting and transit, in the amount of surface blemishes, and in depth of eyes. The losses ranged from 13.8 per cent for Katahdin grown in New Jersey to 27.3 per cent for the White Rose grown in Texas. That this is not entirely a varietal difference is shown by the fact that there was a loss of 22.0 per cent in the Katahdin sample early harvested in South Carolina and only 16.4 per cent in the White Rose from California. As a rule, samples showing 20 per cent loss or less were composed of large uniform potatoes. Losses greater than 24 per cent were due either to a preponderance of small potatoes, or to presence of decay, or to both causes. The losses in preparation are similar to those obtained in this laboratory in Northern-grown potatoes of the same varieties. Peeling with lye was readily accomplished with all samples, the time required being generally less than in the case of late-crop potatoes.

Yields of Dehydrated Product

The yields of the dehydrated product, calculated on the fresh-weight basis, vary from 10.9 to 21.2 per cent. This variation is due primarily to the dry-matter content of the tubers but is affected also by differences in peeling and trimming losses due to the size of tubers and amount of bruising and decay. Since both specific gravity and dry weight are dependent primarily on total-solids content, it is obvious that there is a consistent relationship between them, provided the losses in preparation are fairly constant. The yield is lowest for the samples of lowest specific gravity and increases with increasing specific gravity. This was found to be the case also in the earlier study of fall-crop potatoes. In the present series of samples those having specific gravities of 1.060 to 1.075 gave yields in very good agreement with the Northern-grown potatoes of like specific gravities. The exceptions could be accounted for by differences in preparation losses.

The wide differences in percentages of dry weight is a question of great practical importance. On the basis of 10.9 per cent dry weight, only 218 pounds of dehydrated product would be obtained from a ton of potatoes, but nearly twice that amount, or 424 pounds, would be obtained from a ton of the samples producing 21.2 per cent. The low-yielding samples, in this case Triumph from Texas, had a lower specific gravity than the high-yielding White Rose from California, but the difference in specific gravity alone would not account for the great difference in yield of dehydrated product. It will be noted that

the loss in preparation of the Triumph from Texas was 27.5 per cent and that of the White Rose from California was only 16.4 per cent.

To obtain the best results potatoes for dehydration purposes should be handled carefully to avoid bruising, with its resultant large losses in preparation. The importance of specific gravity determinations as a quick method of approximating the solids content and consequent dry yield of a given lot of potatoes is equally evident.

Relation of Specific Gravity to Maturity

In a number of instances two samples of a variety from the same plot were secured, the first at the time the variety was being dug for market and the second after an interval of approximately 2 weeks. At the time of the first digging the vines were still green; at the time of the second sampling they were dying or dead. In all cases the second sample was higher in specific gravity than the first (Table 1, Chippewa, Irish Cobbler, and Katahdin from South Carolina; Irish Cobbler from Virginia and Maryland). It will be noted that the yield of dry product is always higher in the more mature sample and that the amount of the increase in yield is roughly proportional to the amount of increase in specific gravity.

Quality

After the samples were dry they were reconstituted, cooked, and judged for quality. The dried strips were soaked in water for nearly 16 hours, cooked for 40 minutes, drained, passed through a ricer, and placed on a plate for examination. The material was examined and tested by a group of four judges, all of whom had previous experience in judging similar products. The samples were graded on color, general appearance, texture, and flavor. The judges summed up the scores on these factors and gave each sample a final score for quality.

Each of the original bulk samples was divided prior to drying into two portions, one of which was prepared by the regular salt-dip method and the other immersed for a short time in 0.3 to 0.5 per cent sulfur dioxide solution made by passing the gas from a cylinder into water. The quality scores for both lots are given in table 1 under the headings "regular" and "sulfured". In the final judgments any sample that scored 60 or below was considered poor; 60 to 69, fair or acceptable: 70 to 79, good; 80 to 89, very good; and 90 to 100, excellent. With one exception the samples receiving the sulfur dioxide dip before drying scored higher in quality than those of the corresponding lots prepared by the regular salt-dip procedure. This was due to improvement in

color without any effect upon texture or flavor. Since salt dipping is an approved procedure, whereas use of sulfite is not, further comparisons will be made upon the basis of results secured on the samples prepared in the regular way. High ratings are relatively few. None of the samples was rated excellent; 10 ranked very good, 13 good, 6 fair, and 1 poor. The 23 lots that ranked good, or very good, were widely distributed in respect to variety and place of growth.

As a whole, the dehydrated products made from the Southern-grown material ranked lower in quality than like products prepared by identical methods from Northern late-crop potatoes of the same varieties. It is quite clear that this was due in considerable part to the Southern crop being dug, in accordance with prevailing custom, when the plants were still green and vigorous and the development of the tubers was incomplete.

The five comparisons between early- and late-harvested samples indicate that in every case the quality of the dehydrated product from the late-harvested tubers was one class higher than that from the early-harvested material. It is obvious that if early-crop potatoes are to be used by dehydrators the plants should be allowed to reach full maturity. As a result there would be less waste in preparation, higher quality of dried product, and a considerable increase in yield of dried product per ton and in food value per pound of raw stock, as well as in yield per acre.

Imperfect adaptation of the varieties to conditions under which they were grown may be the basic reason that none of the dehydrated material was excellent in quality. All the varieties in the test originated in the Northern potato-growing districts and owe their popularity to their adaptation to the conditions existing there. All the Northern districts, however much they may differ in other respects, are alike in that they permit potatoes to complete their development in a period in which mean temperatures are progressively decreasing, with relatively low expenditure of photosynthetic products in respiration and consequent rapid increase in storage of starch in the tubers. Production of early-crop potatoes in the Southern districts involves development and maturing of the crop under the exactly opposite condition of progressively increasing mean temperatures with proportionately increased expenditures in respiration and decreased rate of accumulation of starch in the tubers. It is rather improbable that varieties will be found with sufficiently wide adaptation to attain highest quality under such radically different conditions.

Studies on Yellowing During Drying

Practically all the material employed in the study, developed some degree of yellowish coloration during the earlier stages of drying. The intensity of the coloration was quite uniform in any particular sample but varied widely in intensity from sample to sample, and it was most pronounced in the most immature potatoes and decreased with advance of maturity. When this condition was first encountered it was regarded as a part of the general problem of oxidative discolorations initiated by enzymes, and various modifications of the technique employed in preparation were made, and a considerable variety of treatments were applied to the material, in the hope of preventing its appearance. Such treatments included dipping in cold or hot dilute brine, citric or tartaric acid, sodium sulfite, potassium metabisulfite, solution of SO_2 (sulfite) gas in water, and exposure to SO_2 as gas, in addition to the routine blanch in steam. These treatments were entirely ineffective in preventing the appearance of the yellow color, and those involving use of SO_2 or sulfite made the material appear slightly more yellow than steam alone. Drying at temperatures ranging from 140° to 194° F. followed by reduction to lower temperatures for finishing had no effect upon appearance or intensity of color. Substitution of hand peeling for lye peeling was equally without effect. Failure to decrease or prevent the development of yellow color by methods which are effective in preventing pinking or darkening due to enzymic activity or the reddish-yellow to brownish-red discolorations appearing as a result of overheating made it apparent that the condition was distinct from all of these. It is, however, sufficiently like the effect seen in mild cases of overheating to be confused with it. Friar (3) has described yellowing in color of new potatoes when dehydrated, and Cruess and Friar (4) state that "new potatoes are much more prone to yellow than those that have matured well before harvest." They state further that yellowing may be due to any one of several causes and enumerate these as overheating when practically dry, prolonged holding at low drying temperature and high relative humidity at the outset of drying, or use of potatoes direct from cold storage, hence having high sugar content. Wolters, Kerwin, and Copeland (5) in their discussion of various types of discoloration occurring in potatoes have encountered yellowing in potatoes exposed to very low temperatures after harvest or in storage. That the yellowing occurring in our material is due to a factor inherent in the material and not to temperature of previous storage, preparatory treatment, dehydration temperature, or other

external conditions is conclusively proved by several lines of evidence developed in the course of our work. These are:

(1) In overheated dehydrated potatoes, the constituent responsible for the yellowish-red to brownish-red discoloration is readily soluble in water and diffuses out to give a solution ranging from faint yellowish-red to dark brownish-red accordingly as the overheating was slight or prolonged and severe. The constituent responsible for yellowing is insoluble in water.

(2) Discoloration due to overheating begins only after the material is nearly dry and is no longer losing water rapidly hence is at or near the temperature of the air. The yellowish discoloration characteristic of immature potatoes invariably appears within the first 30 to 60 minutes after the potatoes are placed in the drier, hence while the material is losing water rapidly and is far below the air temperatures. It appears quite uniformly over all the material; not in occasional pieces or thinly spread areas as is the case in incipient heat discoloration.

(3) Toward the end of the work with early-crop potatoes, United States Department of Agriculture seedling No. 47148 and Maryland seedling No. 20-2 were received. These normally have rather pronounced yellow color throughout the flesh. Upon preparing and dehydrating these it was apparent that the color of the dry material was identical in quality with that of the other varieties but of much greater intensity. Application of the experimental treatments listed above yielded results of exactly the same character and forced the conclusion that the constituent responsible for the coloration was identical in yellow-fleshed and white-fleshed varieties.

When material of the golden-fleshed seedling varieties was refreshed, the apparent intensity of the color diminished as the material absorbed water but the fully hydrated, cooked material was still very distinctly golden-yellow. When yellow-tinted samples of the white-fleshed varieties were refreshed the color progressively diminishd as the pieces absorbed water and the hydrated cooked material was normally white, but became yellow again on redrying. Samples alternately refreshed and dried five successive times were indistinguishable in color after the last drying from check lots not so treated. The water used for soaking remained perfectly colorless, so that the constituent responsible for the coloration is insoluble in water, unlike that found in cases of discoloration from overheating.

(4) About 25 varieties of potatoes that were grown in Maine and matured in September were dehydrated. In the early and midseason varieties the tops had died down prior to digging; in the late-maturing

ones unusual seasonal conditions prolonged the life of the plants, and they remained green and vigorous until killed by chemical treatment to permit digging. This physiologically immature material developed rather decided yellow coloration during drying; the early-maturing, hence normally matured varieties, had a faint but perceptible tinge of yellow.

(5) Storing potatoes at low temperatures until their sugar content is high, and then dehydrating them intensifies yellow coloration originally present. Material of a number of varieties, some of which were grown in Maine and others in Maryland, have recently been dehydrated after storage for approximately 2 months at various temperatures from 32° to 60° F. Portions of the Maine-grown material, dried at the beginning of the storage period, had shown varying but not pronounced degrees of yellow. Like tests, unfortunately, were not made upon the Maryland potatoes, so that it is not known whether they were yellow when placed in storage. At the end of the storage period all the material, regardless of variety, place of growth, or storage temperature, was pale yellow when dry, but that from 32° storage was somewhat deeper in color than that from the higher storage temperatures. Both 32° and 40° lots were quite sweet.

(6) Study of the chemical nature of the yellowish coloration is in progress but incomplete. Its solubility in various reagents strongly indicates relationship to the carotinoids. Preliminary determinations of total carotinoids upon both golden-fleshed and white-fleshed varieties to the number of about 25 suggest the presence of carotinoids in all in amounts roughly agreeing with the apparent intensity of the yellow color in the dry product.

It is our present opinion that the yellowing at the outset of drying here discussed is due to the presence of constituents, possibly carotinoid in nature, which are normally present in all potato tubers.* In relatively large amounts they give the flesh of the fresh potato a distinct yellow color; in smaller amounts, a pale cream or ivory tint. As the tubers mature this constituent may be reduced in amount, but never wholly disappears. More probably, its presence is progressively masked as the cells become filled with starch. It again becomes apparent when the tubers are dehydrated, as a consequence of concentration due to drying and the translucence of the pieces resulting from partial gelatinization of the starch. When potatoes high in starch

* Chromatographic analysis of the pigment by Herbert Wiseman, Bureau of Dairy Industry, and B. C. Brunstetter, Bureau of Plant Industry, definitely confirms this opinion.

content are dried, the color may be only very faint cream; in those which are low in starch content, it will appear as a yellow tint. If this reasoning is correct, the appearance of some degree of uniformly distributed yellowish coloration at the outset of drying may be anticipated in potatoes harvested in very immature condition, in those grown under conditions that are unfavorable to the development of normal starch content, and in those stored at such temperatures that considerable quantities of their starch have been converted to sugar.

Summary

The results of a study of the suitability for dehydration of Southern early-crop potatoes, and of the comparative quality of the dehydrated product made from the principal varieties grown in the chief early-crop districts are reported. The work is essentially a continuation of an earlier study in which material of the important varieties from the late,—or main-crop states are used.

The samples were supplied by cooperators in the national potato-breeding project in the states of Texas, Florida, Louisiana, South Carolina, Virginia, California, Maryland, and New Jersey. Each cooperator supplied the varieties that are of greatest commercial importance in his state. Irish Cobbler and Katahdin were each represented by material from five states; Chippewa, from four; Triumph and Sebago, each from three; White Rose, from two; and Sequoia, Pontiac, and Red Warba, each from one. The material was dug at the time of commercial harvesting in each district, but in addition samples of certain varieties were taken after the plants had matured. As the various lots were dug they were shipped to Beltsville, Maryland, and dehydrated within 2 or 3 days after they were received. The dates of receipt ranged from the 25th of May to the 31st of August, so the work was intermittent but the techniques of preparation and drying were carefully standardized in order that all samples might receive uniform treatment. The methods used were the same as those described in a former publication (1).

All commercially harvested samples, regardless of variety or place of production, were immature, as shown by their small size and the loosened and frayed skins. All were low in total-solids content, with specific gravity readings of 1.035 to 1.075, most of them being below 1.060. The percentages of starch and of dry product were correspondingly low. In the delayed-harvest samples the average size of tubers was greater, specific gravity higher, peeling losses lower, and dry yields

larger than in the corresponding commercially harvested lots from the same plots.

The weight of dry product expressed as a percentage of fresh material ranged from 10.9 to 21.2 per cent. When losses in preparation were about the same there was a consistent correlation between specific gravity of the fresh tubers and yield of dry product. When prepared and cooked as riced potatoes none of the samples was excellent in quality. Twenty-three lots ranked good to very good. These were widely distributed in respect to variety and place of growth; hence neither a variety nor a district was consistently very good or consistently poor in quality of product.

The more mature samples were higher in total solids, and there was an improvement in the consistency and mealiness of the cooked product.

The tendency to develop gray or dark discoloration during preparation for drying is most pronounced and difficult to control in immature potatoes regardless of variety, and decreases with advancing maturity. It was controlled somewhat in very immature lots by dipping into salt solution prior to blanching, and was very satisfactorily prevented by dipping into dilute solution of sulfur dioxide in water. Concentration of the solution and length of dip could be so regulated that protection was effective without excessive retention of sulfur or alteration of flavor.

In all lots a yellow coloration affecting all parts of the sample uniformly became apparent within 30 to 60 minutes after being placed in the dehydrator. It differed in intensity with stage of maturity, being most pronounced in very immature samples but still perceptible in the most mature lots. It was distinct from enzymic or oxidative darkening and was not inhibited or reduced by preparatory treatments which effectively prevent such discolorations. Incomplete studies of its cause have shown the presence of carotinoids in all potatoes examined, roughly varying with the intensity of the coloration present in the dehydrated product.

As a whole, the dehydrated products made from early-crop potatoes rank significantly lower in quality than those made by identical methods from late-crop potatoes of the same varieties. This result is due to some extent to the custom in the South of harvesting when the plants are still green and vigorous and the tubers immature. It may be due in part to imperfect adaptation of existing varieties to the climatic conditions under which the early crop is grown. The low yields

and absence of highest quality in the dehydrated products made from immature potatoes indicate that potatoes intended for dehydration should be allowed to mature before digging.

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RELATION OF SAMPLE SIZE TO ACCURACY

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A recent proposal by Fitch (1) is that seed potato inspectors count and record the number of diseased plants in 10,000 plants rather than recording these in tenths of a per cent or by terms such as 'trace" or "present." Dr. Fitch's confidence in the competence of our inspectors is flattering but not well founded and his proposal ignores the important and largely unpredictable role often played by current season spread of virus diseases. A recent study of split-tuber plantings indicates that experienced inspectors are likely to detect about 80 per cent of the leaf roll and that this percentage is likely to vary for the same individual over a considerable range for very slight changes in conditions. Such changes might occur in going from one part of a field to another, or by reason of a few days growth. This suggests that a field in which one inspector had counted 5 diseased plants in 10,000 might actually be less free from disease than one in which another inspector on a different date had counted 50 or 100. We have also had experiences in which stocks showing no leaf roll (more than the requisite 10,000 having been examined) have shown 15 to 40 per cent the following year whereas fields which have plainly shown more than the tolerance have produced seed entirely suitable for certification.

When samples are taken directly from the stock produced, for testing in the south or for greenhouse tests, the above arguments with

respect to current season spread do not apply but those with respect to competence of inspectors and influence of environmental conditions on symptoms do. Errors due to these causes will persist regardless of doubling and redoubling the size of samples.

Errors caused by the laws of chance regarding sampling are also unavoidable but these can be reduced by increasing the size of the sample, assuming that due precautions are taken to draw the sample fairly. This improvement can be placed on a mathematical basis as has been done by Folsom (2). He presents a formula and table and concludes that a sample of 7,369 tubers are necessary at a reading of 1.5 to 2.0 per cent.

The author has adopted a different mathematical and philosophical approach to the problem. Dr. Folsom has assumed that odds of 30 to 1 are required. Such odds or even higher ones may be required to establish a scientific truth which may serve as a more or less permanent guide for thousands of persons. Individual business decisions are commonly based on much lower odds, sometimes as low as 2 to 1. The decision on any one sample is a business one involving one year's operations for a small number of persons. Odds of 10 to 1 are probably adequate for such a decision. Folsom also assumes that the question to be decided is whether the percentage found differs from either of two assumed means at equal intervals on either side of it. It appears to the author that the question to be decided is more commonly whether the percentage found is significantly less than a given mean (sometimes whether it is significantly more than a given mean, but not both.)

With regard to the upper and lower limits selected it must also be recognized that these are arbitrary and approximate. If, for instance, we grant that a table-stock grower can plant stock containing 9 per cent leafroll without appreciable loss, we cannot assume that planting stock containing 10 per cent leafroll will result in financial disaster. Also if foundation stock containing 1 per cent leafroll is entirely satisfactory, stock containing 1.5 per cent will not be altogether worthless for the purpose.

Because of the extreme skewness of the frequency distribution curves of small samples from stock containing small percentages, it has seemed to the author inadvisable to depend on such a formula as that used by Folsom. These curves can be constructed by calculating the successive terms of the expansion of $(p + q)^n$ where p is the proportion of the stock healthy and q is the proportion diseased and n is the number of tubers in the sample. These terms have been calculated for $q=1$ per cent and $q=2$ per cent and for values of n of 100, 200, 400

and 800 and are presented in table 1. From this table it can be learned that, with stock containing 1 per cent disease, 100 tuber samples will show records of no disease in approximately 37 per cent of the cases

TABLE 1.—*Probability of obtaining a given number of diseased plants in a sample of given size from stock containing a given percentage of disease.*

Number of Diseased Plants	Percentage Disease in Stock Sampled							
	1				2			
	100 Tuber Samples	200 Tuber Samples	400 Tuber Samples	800 Tuber Samples	100 Tuber Samples	200 Tuber Samples	400 Tuber Samples	800 Tuber Samples
	100	200	400	800	100	200	400	800
0	.366	.134	.018	.000	.133	.018	.000	
1	.370	.271	.073	.003	.271	.072	.002	
2	.184	.272	.146	.011	.274	.146	.010	
3	.061	.181	.196	.028	.182	.196	.028	
4	.015	.090	.196	.057	.090	.197	.056	
5	.003	.036	.157	.092	.035	.158	.091	.001
6	.001	.012	.104	.122	.011	.105	.122	.002
7		.003	.059	.140	.003	.059	.141	.006
8		.001	.029	.140	.001	.029	.142	.012
9			.013	.124		.013	.125	.021
10			.005	.099		.005	.100	.034
11			.002	.072		.002	.073	.049
12			.001	.048		.001	.048	.066
13				.030			.029	.082
14				.017			.017	.094
15				.009			.009	.100
16				.005			.004	.100
17				.002			.002	.094
18				.001			.001	.084
19								.070
20								.056
21								.042
22								.031
23								.021
24								.014
25								.009
26								.005
27								.003
28								.002
29								.001
30								.001

whereas with a 200-tuber sample the number of zero readings will be reduced to 13 per cent of the cases. We can state this in the following form. "When stock contains one per cent disease, the odds are 2 to 1 against drawing a 100-tuber sample containing no disease and about

7 to 1 against drawing a 200-tuber sample containing no disease." Can we invert this statement to read "When a 100-tuber sample contains no disease the odds are 2 to 1 that the stock from which it comes contains no more than 1 per cent disease?" Unfortunately, such inversions are mathematically unsound. If the question is stated "What are the odds that samples of 100 tubers from stock containing 1 per cent disease will not show more than 3 per cent disease?" the answer will be found by adding the terms in the 100-tuber column from that opposite number 4 to 6, giving .019. This is the probability of samples showing 4, 5, and 6 plants. (Probability of higher percentages are negligible). Subtracting from 1 gives .981, the probability of percentages 0, 1, 2 and 3. Dividing the latter figure by the former gives the odds, which are 52 to 1. If 200-tuber samples are being considered, we begin with the term opposite 7 (since 6 tubers will mean 3 per cent); if 400-tuber samples, begin with term 13; and if 800 tuber samples, begin with term 25, (In the last two cases the odds are infinitely great).

It may be noted that the values in the first three columns for stock containing 2 per cent are almost identical with those in the last three columns for stock containing 1 per cent. This relationship is general and we may therefore use the values in the 100-tuber column for 1 per cent to determine the situation with respect to 50-tuber samples from stock containing 2 per cent and those from the 800-tuber column under 2 per cent to represent the situation in 1600-tuber samples from stock containing 1 per cent. The laborious calculation of values for other such distributions may be avoided by reference to Karl Pearson's table 51 (3). "Poisson's Exponential Binomial limit." Although this table is based on an approximation it gives practically the same values to three decimal places as would the binomial expansion unless samples smaller than 50 are involved.

Table 1 and Pearson's table 51 (also his table 52 and 2) have been used to derive table 2 which shows the approximate range most likely for samples taken from stocks containing given percentages. For example, if we find a 100-tuber sample showing no disease it may well have come from a field containing 1 or 2 per cent disease but is unlikely to have come from a field containing as much as 3 per cent. If the sample shows 3 per cent it may have been taken from a lot containing 2 per cent or more but not likely from one containing as little as 1 per cent. The gain in accuracy resulting from larger samples is readily apparent from an examination of table 2. It must be recog-

TABLE 2.—*Minimum and maximum percentages likely to be found in samples of size indicated when taken from stock showing indicated percentages,* (10 *to* 1 *against either less or more,* 4.5 *to* 1 *against both*). (4)

Size of Sample	Per Cent Present in Stock Involved								
	1	2	3	4	5	6	8	10	15
50	0-2	0-4	0-6	0-8	2-10	2-10	4-14	4-16	8-22
100	0-2	0-4	1-5	2-7	2-8	3-9	5-11	6-14	10-20
200	0-2	1-3.5	1.5-4.5	2.5-6	3-7	4-8	5.5-10.5	7-13	11.5-18.5
400	0.5-1.8	1.2-3	2-4	2.8-5.2	3.5-6.5	4.5-7.5	6.2- 9.8	8-12	12.5-17.5
800	0.5-1.5	1.4-2.6	2.2-3.8	3.1-4.9	4-6	4.6-7.4	6.8- 9.2	8.5-11.5	13.2-16.8
1600	0.6-1.3	1.5-2.5	2.4-3.6	3.3-4.7	4.2-5.8	5.2-6.8	7.1- 8.9	8.9-11.1	13.7-16.3

(4) This table was derived from table 1 for values covered by that table, from table 51 and 52 of Pearson for higher limits covered and from Pearson's table 2 for higher values.

nized, however, that even with the largest practicable samples it is impossible to sort accurately to a definite tolerance. If, (referring to table 1), we set a tolerance of 2 per cent for foundation stock we will reject nearly one-half of the stock which actually has 2 per cent together with a small percentage of stock which has 1 per cent, (or intermediate amounts, which do not happen to be recorded in the table). We also accept nearly one-half of the stock containing 2.1 per cent. Further, if we strive for great accuracy in the matter of sample size we may only be forging a very strong link in a very weak chain.

It will readily be seen that the author's conclusions as to what constitutes an adequate sample of potatoes for test purposes differ very markedly from the opinion indicated by Folsom. This is due, not so much to the different mathematical method, as to the different criteria adopted for adequacy. Thus, in the case cited by Folsom where 2735 tubers are suggested with 3 per cent disease present to show that the true amount lies within one per cent of this amount, the author's argument would be that 400 tubers would be adequate, since we would be satisfied to know the probability that variation was in one direction only and would require odds of 10 to 1 rather than 30 to 1. In practice we usually find it impossible to use samples even of this size so must be satisfied with an error of 2 per cent rather than 1 per cent.

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SECTIONAL NOTES

CALIFORNIA

The big rush has ended with the harvesting and disposal of 50,300 acres of Irish potatoes. We have not been able, as yet, to get the total car-lot shipments from Kern County.

Our peak shipments this year by rail reached well over 800 cars per day which is more than 200 cars per day,—more than we had ever shipped before from Kern County.

We started digging this year about 30 days late because of two factors. These factors were the OPA price ceiling schedule and the frost that hit us about the middle of March.

The growers this season have paid in the neighborhood of 75 cents per hour with, of course, some variation. Some of the work was done piece work. We will have approximately 3,000 acres in the Tehachapi area which will not be harvested for another 30 to 60 days. Some of this will be used for seed,—the rest will go as matured potatoes.

A large number of new growers grew potatoes in this vicinity for the first time this year. In many cases they lost money,—first, on account of the price of potatoes at market time, and secondly because of poor yields due to poor quality seed. (July 31).—M. A. LINDSAY.

INDIANA

The potato prospects dropped about 60 per cent in Indiana this past month because of the drought, hot weather, and leafhoppers. A month ago Indiana was a bumper crop state.

The late-maturing potatoes on the muck as well as on upland soils are about 65 per cent of normal and will need good weather and continued pest control before the crop is made.

There was a general July rain over most of the Middle West on the 25th of July, but it was very light and arrived too late. (Aug. 1)—W. B. WARD.

NEBRASKA

Final plantings on Nebraska Certified potatoes were reported on the first of July, and show a moderate increase in plantings compared with 1943. Because of the severe hail storms that destroyed other crops in the irrigated areas, our potato planting season extended far beyond the usual period which generally ends the latter part of June. Some potatoes were still being planted during the week of the 17th of July, even though the prospects of a good yield were relatively poor at that time. Our potatoes still have a better chance of maturing than practically any other crop that has been planted at so late a date.

The month of July was relatively cool, with ample moisture, and most of the potato crop developed rapidly, and soon recovered lost ground on account of late planting. For the past week (before August 10), the temperatures have mounted rapidly, and that, with excessive high winds, has caused considerable tip burn, and set the crop back materially.

Extensive spraying is being conducted on potatoes, both certified and commercial, for psyllids, flea beetles and blister beetles. The psyllid population is higher than for several seasons past, and grasshoppers are beginning to be a menace again this season.

With the advent of cooler weather, the potato crop will probably recover from the damage that has already taken place, since there should still be five or six weeks of growing weather before the first frost. Of course, much depends upon the weather in the immediate future. (Aug. 14)—MARX KOEHNKE.

NEW JERSEY

Approximately forty per cent of our potato crop is now harvested. Practically all our Cobblers and Chippewas have been shipped and many growers are now harvesting Katahdins. The yields have been most variable,—with the average ranging about seventy sacks per acre. The varieties Chippewa and Katahdin have in most instances outyielded Cobblers. We have experienced extreme heat and drought during the entire month, with the exception of the rainfall on the 2nd and 23d of August, when a good rain fell throughout the entire state. The rainfall during July was the lowest in 72 years at Trenton, a total of .37 of an inch being recorded. The temperature has averaged 4 degrees above normal since the 1st of May, and there have been 28 days when the temperature reached 90 degrees or higher.

Our seed crop was planted in very hot, dry soils, consequently causing some very poor stands. The rainfall on the 2nd and 3rd of August has brought the crop along fairly well, but for favorable growing conditions additional rain is greatly needed at the present time. (Aug. 19)—J. C. Campbell.

NEW YORK

Long Island's big potato county, that is Suffolk, has had the lowest rainfall in the two largest potato towns of Riverhead and Southold during the past 30 years. At the Long Island Vegetable Research Farm the official record of rain, for the period from the 28th of April to the 31st of July, has been 2.62 inches. There was no measurable rainfall during July.

The early varieties of potatoes are yielding from one-half to two-thirds of a normal crop. To date, in addition to the drought we have had the warmest summer that we have experienced for many years.

The Green Mountain crop in Eastern Suffolk is nearly dead and cannot yield more than a quarter to one-third of a crop.

Some of the less important potato growing areas of Suffolk have

had scattered showers and will therefore have a better crop. (July 31).—H. R. TALMAGE.

The August 1 potato crop report for New York indicates a reduction from the July 1 report estimate of six and one-half million bushels or 22 per cent. Nearly all of this reduction is the reflection of the serious effects of drought during the month of July.

Long Island was the most seriously affected and it is estimated that the drought reduced the crop there to approximately one-half that of 1943. The magnitude of this situation can be appreciated by the fact that Long Island plants about 25 per cent and produces about one-third of the total New York crop. The damage was, of course, most serious in the later varieties. Late potatoes on the Island are so seriously affected that the crop cannot be redeemed by favorable weather from now on. Rains finally came on the 3d of August and again on the 6th of August, these being the first rains since late June.

In upstate New York July rainfall was only about one-half normal in most of the potato counties. However, the effects of the drought did not begin to show seriously until the last week of July and the first two weeks of August. The early symptoms of late blight largely disappeared except in a few of the better fields in isolated regions where local showers made conditions favorable. Among the important potato counties in best condition at this date, the 15th of August, are Steuben, Washington, and Rensselaer. The potato crop in such important central New York potato counties as Oneida, Onondaga, Oswego, Monroe and Ontario suffered greatly from drought during the first two weeks of August. Fairly general rains came on the 14th of August as a result of which the crop will be "saved" in many counties. A fair crop of potatoes is in prospect on most of the important muck soil areas.

The harvesting of the muck crop and of the early-planted upland crop upstate began early in August. In Steuben County where most of the acreage is planted to Katahdin, harvest has already begun. The two factors most responsible for this early harvest are that the crop was planted under favorable conditions early in May, and that the present favorable price level is encouraging harvest before the crop is mature. The O.P.A. ceiling price increase of 90 cents a hundredweight will be of good financial benefit to the Long Island grower and to other growers whose crop has been permanently injured by the drought. Unless a favorable ceiling price is maintained during the fall harvest period, there may be a tendency to market the earlier maturing fields during late August to take advantage of the August ceiling

price schedule. It is expected that an effort will be made to maintain the present August ceilings through September, at least. (Aug. 15).—E. V. HARDENBURG.

OHIO

As a result of the drought and the hot weather, Ohio has about one-half the crop of early potatoes. The crop in the Cincinnati area was reduced to one-fourth; but in northeastern Ohio, where few early potatoes are grown, there has been more rain and the yields are better. Growers throughout the entire state have started harvesting operations and the yields are ranging from 100 to 125 bushels to the acre compared with our normal yields which usually range from 200 to 250 bushels.

The drought has not been broken; therefore, the late crop of potatoes has been hurt. We figure that the crop has been reduced about one-fourth now and unless rain comes soon this reduction will be even greater.

Even though the ceiling price has been increased, Ohio potatoes are selling on the black market. These black market prices are caused partially by the confusion on the interpretation of the potato regulation by O.P.A. offices and largely by the 60-cent markup permitted between the grower and the retailer,—part of this 60-cent markup is being given to the growers. Ohio growers feel that the O.P.A. should either simplify its regulations or interpret them so that every one would know what his ceiling price really is. Part of the confusion in this state has been caused by the variations in freight rates. Ohio needs a flat freight rate. (Aug 9).—EARL B. TUSSING.

OREGON

A total of 1,576.6 acres of potatoes was entered for certification, including the following varieties: Russets, 679.1 acres; White Rose, 865; Burbanks, 30; and 2½ acres of Katahdins in Klamath County alone. Of this number 108.5 acres were rejected on the first field inspection, and 45 acres withdrawn,—making a total, to date, of 1,423.1 acres that have passed inspection.

There is more than usual interest in seed plots and the growing of commercial certified seed.

Our season was particularly backward until the 4th of July,—with cold nights and considerable rain. Since that time it has been favorable for growth,—with an unusual number of thunder showers in the afternoons. As a result, the potato crop was almost in a normal condition

on the 1st of August. The acreage for the Klamath district is now estimated at 25,500, or it is approximately 1,500 acres greater than in 1943. (Aug. 1).—C. A. HENDERSON.

PENNSYLVANIA

During the past month our potatoes have suffered from dry weather and although the yields of our early varieties have been reduced, our late varieties will still make a good crop providing we have sufficient rains during the month. Our stands have been poor, and leafroll and other virus diseases have been more common than usual—even though a larger percentage of the crop has been planted from certified stock.

Late blight is present in the mountain areas of Tioga and Potter counties in damaging amounts, and is widely scattered throughout the state,—although not causing loss. (Aug. 14).—O. D. BURKE.

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FIELD COMPARISONS OF COLLOIDAL PHOSPHATE AND SUPERPHOSPHATE AS SOURCES OF PHOSPHORUS IN POTATO FERTILIZERS

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INTRODUCTION

For a number of years *now* a phosphatic material known as Colloidal Phosphate or Waste-pond Phosphate has been offered for sale in different parts of the country and recommended as a source of phosphorus for the growing of crops. Claims have been advanced for this particular phosphate that it possesses considerable crop-producing value. These claims are based largely on the particle fineness of the material and on its alleged content of beneficial nutrient elements other than phos-

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phorus. The material has been designated by the Association of Official Agricultural Chemists as "Soft Phosphate with Colloidal Clay," and this Association has adopted as official the following definition:

> A very finely divided low-analysis by-product from mining Florida rock phosphate by a hydraulic process in which the colloidal material settles at points in artificial ponds and basins farthest from the washer and is later removed after the natural evaporation of the water.

Because of the contaminating clay it contains, the material has a comparatively low phosphoric acid content, usually ranging from 18 to 23 per cent P_2O_5. Because of this clay content the material possesses such a high content of iron and aluminum compounds that it is not at all suitable for the production of superphosphate by acidulation with sulphuric acid. For these reasons Colloidal Phosphate has been offered for sale chiefly for direct application to the soil, because, obviously, such a highly insoluble material cannot qualify as a source of phosphorus in commercial fertilizers in the way that superphosphate, triple superphosphate, and monoammonium phosphate (Ammo-Phos) do.

Notwithstanding the fact that the phosphorus in Colloidal Phosphate is practically water-insoluble and that very little of it is soluble in neutral ammonium citrate solution, the material has been offered for sale in different potato-producing regions with the implication that it can be used as a source of phosphorus in potato fertilizers. In Maine and in other potato-producing states potato growers have been approached from time to time on the subject of buying the material for use in the home-mixing of their fertilizer.

It is generally conceded that a growing crop of potatoes requires its plant nutrients, including phosphorus, in quickly available forms. This is borne out by the fact that potato fertilizers are formulated with an available phosphate, or one that is water-soluble. Obviously, any attempt to employ an insoluble material such as Colloidal Phosphate as a source of phosphorus in potato fertilizer would defeat itself automatically, simply because it would be detected as soon as any such fertilizer mixture was analyzed by a state fertilizer control agency.

Object of Present Study

Because of the wide publicity given Colloidal Phosphate, and because it had been suggested as a source of phosphorus for potato production, the material was subjected to a series of comparative field

trials in Maine, New Jersey, Pennsylvania and Virginia.[4] In these trials, all conducted on a comparable basis, Colloidal Phosphate was used as the source of phosphorus in comparison with superphosphate. This afforded a fairly simple and direct comparison. In addition to obtaining yield records, information was obtained at certain locations on the comparative influence of the respective phosphorus sources on emergence, tuber development, and vine growth.

Experimental Details

In Maine, New Jersey and Pennsylvania the two phosphates were formulated as 4-8-7 mixtures with nitrogen and potash materials. In Virginia the fertilizer mixture employed was a 6-8-6. Nitrogen sources used in all the tests consisted of sodium nitrate, furnishing 25 per cent of the total nitrogen; ammonium sulfate, 50 per cent; fish scrap and tankage, each 12.5 per cent. Potash was derived from muriate of potash (50 per cent K_2O). Calcined "Kieserite" was added to all fertilizer mixtures to furnish available magnesium at the rate of 30 pounds of MgO (Magnesium oxide) per ton of fertilizer. A no-phosphorus mixture, containing only the nitrogen and potassium ingredients, was included as a control in most of the tests.* As a general rule, the experiments were conducted on a row basis, the length of row harvested being 200 feet. Four to six replications of each treatment were run in the various field trials.

In applying the fertilizer the two-band method of placement was usually employed. However, in the 1931 and 1932 tests in Maine and in Virginia the rows were furrowed out and the fertilizer was applied by hand, later being worked into the soil with a cultivator. The rate of application in Maine, New Jersey and Virginia was 2,000 pounds per acre; in Pennsylvania, 1,200 pounds. The varieties grown were: Green Mountain in Maine, Irish Cobbler, New Jersey and Virginia, and the Russet Rural in Pennsylvania. The yield data are given in table 1 with certain subsidiary information regarding the soils on which the tests were conducted.

Discussion of Results

An examination of the yield results given in table 1 shows that in all tests superphosphate was a better source of phosphoric acid for potatoes than was Colloidal Phosphate. In Maine the yield increase ranged from 18 to 149 bushels per acre; in New Jersey the superphosphate mixture produced 27 bushels more than the Colloidal Phosphate

*Contained Kieserite.

TABLE 1.—*Results of field tests comparing Colloidal Phosphate and Superphosphate as sources of phosphorus.*

Source of Phosphorus	Potato Yields per Acre												
	Aroostook County, Maine[1]								Middlesex[2] County, N. J.	Lehigh[3] County, Pa.		Fairfax[4] County, Va.	
	1931		1932		1937		1938		1937	1937	1938	1937	1938
	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.
No phosphorus	[5]	[5]	[5]	[5]	312	429	297	319	217	...	...	106	160
Superphosphate	375	437	428	570	392	483	390	330	240	315	440	165	249
Colloidal phosphate	226	353	326	322	303	464	304	312	213	291	415	112	174
Increase for superphosphate	149	84	102	48	89	19	86	18	27	24	25	53	75

[1]Soil type: Caribou loam, pH 5.2 to 5.4. Two tests made each year the work was conducted.

[2]Soil type: Sassafras loam, pH 5.3.

[3]Soil type: Berks shale loam, pH around 5.4, although usually higher (6.0 to 6.5) elsewhere. From results obtained in rate-of-phosphorus studies this soil requires added phosphorus to insure maximum potato yields.

[4]Soil type: Norfolk loamy fine sand, pH 5.0 to 5.3.

[5]The Caribou loam soil is responsive to phosphorus treatment, as indicated in other tests (1937-'38).

NOTE: The Colloidal Phosphate used in the various trials had a total P_2O_5 content of 18.9 per cent; the superphosphate, 20.13 per cent total of P_2O_5, of which 19.8 was rated as available (water and ammonium citrate soluble).

mixture; in Pennsylvania approximately 24 bushels more per acre; and in Virginia 53 and 75 bushels, respectively, for the two tests conducted.

The results clearly indicate that any attempt to displace superphosphate with Colloidal Phosphate in potato fertilizers will lead to reduced yields and profits.

Additional Comparisons

The influence of the respective phosphates on vine and tuber development was determined on vine and tuber samples collected from tests made in Maine and Virginia. Results obtained in Maine showed clearly that the more available phosphate - superphosphate — produced heavier vine growth and a greater number and weight of tubers. The comparative influence of the two phosphates on tuber set is indicated in figure 1.

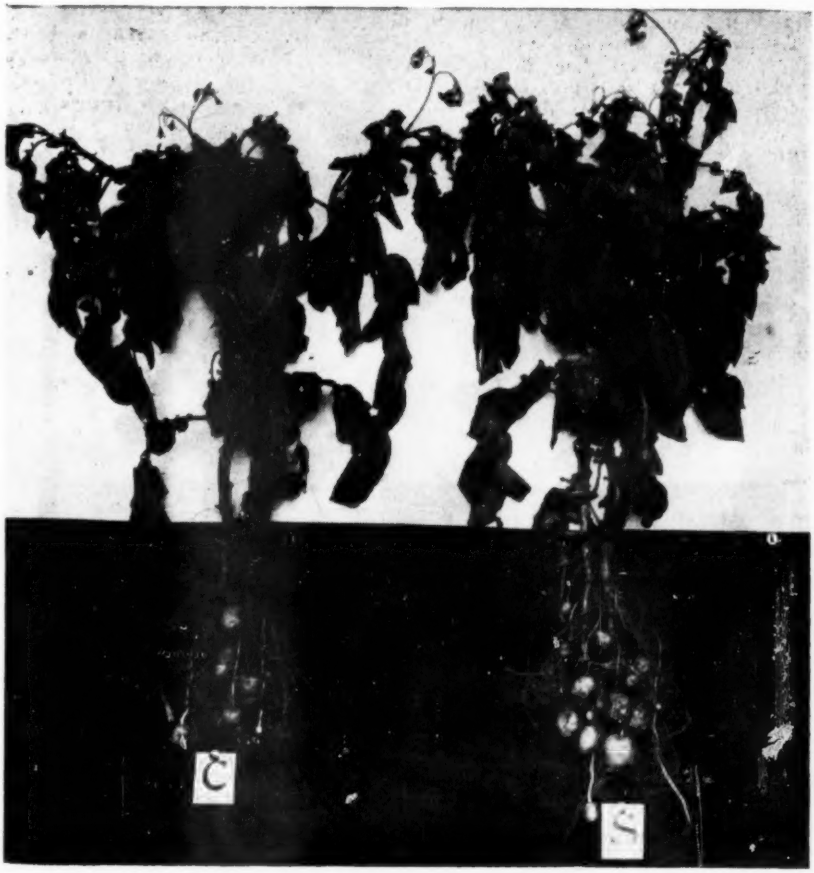

FIGURE 1.—Comparison of potato plants with tubers attached (Maine): *C*, Colloidal Phosphate the source of phosphorus, *S*, Superphosphate the source of phosphorus.

In Virginia tests it was observed that the rate of plant emergence was more pronounced where superphosphate was used as compared with Colloidal Phosphate as the source of phosphorus. Each treatment was replicated 10 times with 185 seed pieces per row for a total of 1,850 seed pieces. In 1937 the potatoes were planted on the 8th of April and a plant count which was made on the 10th of May, gave a total of 1,757 plants above ground for superphosphate, and only 1,522 for the Colloidal Phosphate, a difference of 235 plants. A later count in June showed that practically all plants had emerged, but that the vine growth was noticeably thriftier throughout the growing season where superphosphate was used.

FIGURE 2.—A further comparison of potato plants with tubers attached (Virginia):
Left, Colloidal Phosphate as source of phosphorus,
Right, Superphosphate as source of phosphorus.

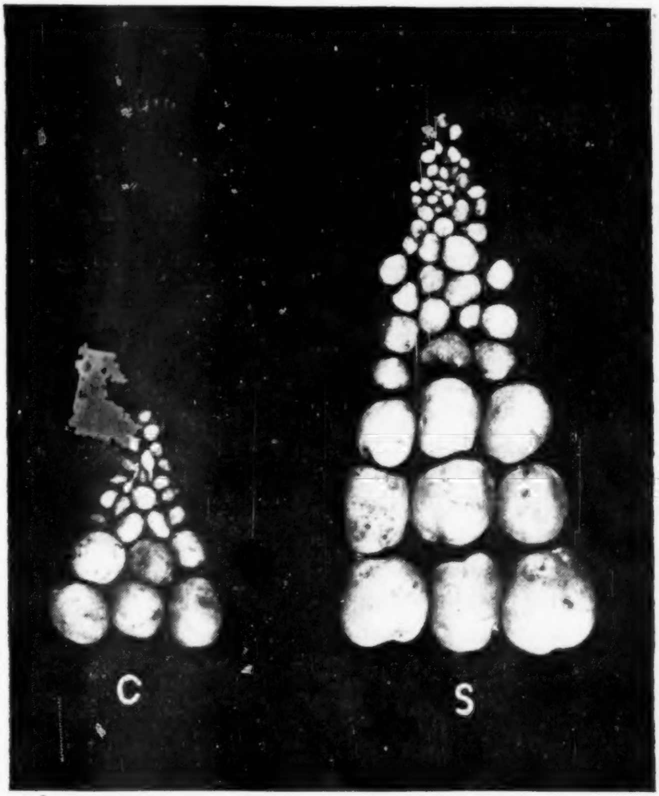

FIGURE 3.—Total tubers from five hills of potatoes, Irish Cobbler (Virginia):
C, Colloidal Phosphate,
S, Superphosphate.

At harvest a count of tubers obtained from each phosphate source gave 5,291 primes for superphosphate and 4,153 for Colloidal Phosphate, a difference of 1,138 tubers in favor of superphosphate. In figure 2 is shown a comparison of the respective vine growth and attached tubers, and in figure 3, the total tubers from 5 hills of each phosphate treatment. It is fairly obvious that the more vigorous vine growth and the increased tuber set were the principal factors contributing to the larger yields obtained with the superphosphate treatment. The comparative influence of the two phosphates on potato vine weight (five plants) and number and weight of tubers is shown in table 2.

TABLE 2.—*Vine and tuber development*[5] *resulting from the two phosphate treatments in the Virginia study, 1937.*

Source of P_2O_5 in 6-8-6 Fertilizer	Dry Weight of Vines	Tubers	
		Number	Weight
	Grams		Grams
Superphosphate	270	47	200.0
Colloidal Phosphate	191	27	85.5
Difference	79	20	114.5

[5]Irish Cobbler variety.

It is clear from the foregoing data that the superphosphate treatment exercised a more favorable influence on vine growth and tuber development than did the Colloidal Phosphate.

In considering the indicated influence of the more available phosphate on emergence, vine growth, and tuber development a statement made by Harrington and Pollinger of the Montana Agricultural Experiment Station (6) is of interest. They state that phosphate-fertilized potato plants emerged before those not fertilized, made a more rapid early growth, and showed a larger root development, together with an earlier and heavier set of tubers, and that the phosphate treatment usually improved both yield and tuber quality.

RESULTS OF OTHER WORK

Apparently very little experimental work has been done to evaluate Colloidal Phosphate as a source of phosphoric acid for potato fertilizers. The only reference found concerned studies made by White-Stevens (7) who reported that soft or Colloidal Phosphate compared favorably with superphosphate in the production of potatoes grown on Sassafras silt loam on Long Island. It would have been of considerable interest and value had a no-phosphorus treatment been included as a means of determining whether the soil on which the tests were conducted were in need of phosphorus.

[6]"Potato yields and quality," Mont. Agr. Exp. Sta. Bul. No. 392, 20 pp., 1941.

[7]White-Stevens, R. H. Effect of different sources of phosphorus on the production of potatoes on Long Island. Amer. Potato Jour. 19(5):81-90. 1942.

SUMMARY

Superphosphate, triple superphosphate, and mono-ammonium phosphate (Ammo-Phos) are the main sources used to supply phosphorus in potato fertilizers. As is generally recognized, growing potato plants require relatively large amounts of readily available plant nutrients. Although the amount of phosphorus absorbed is only about one-eighth to one-fourth of the amount of nitrogen and potash absorbed, the source of phosphorus must also be readily available to meet the needs of the potato plant for this essential plant nutrient. For a number of years a material designated Colloidal or Waste-pond Phosphate has been on the fertilizer market; at least it has been offered for sale to farmers who use fertilizer for crop production purposes. Potato farmers have been solicited to purchase the material on the strength of statements that its phosphorus is available and that, moreover, it has additional merit because of its content of certain so-called minor or secondary nutrient elements.

Field studies have been made in Maine, New Jersey, Pennsylvania, and Virginia to compare Colloidal Phosphate and superphosphate as sources of phosphorus in potato fertilizers, the results of which have shown:

1. In all field comparisons,—a total of 13 having been made,—potato plants receiving fertilizer mixture formulated with superphosphate produced greater yields than those receiving the fertilizer mixtures which had Colloidal Phosphate as the source of phosphorus. In Maine, the average increase for 8 tests was 68 bushels per acre in favor of superphosphate; in New Jersey, 1 test, 27 bushels per acre; in Pennsylvania, average of 2 tests, 24.5 bushels per acre; and in Virginia, average of 2 tests, 64 bushels per acre.
2. The more favorable influence of the superphosphate fertilizers on earlier emergence, vine development, tuber set, and number of marketable tubers produced was pronounced.
3. The results reported herein afford a pattern showing (1) that the use of Colloidal Phosphate as a source of phosphorus in potato fertilizers is not justifiable, and (2) that the maintenance of normal vine growth and maximum potato yields requires the use of a material high in available phosphorus as the source of phosphorus in potato fertilizers.

EFFICACY OF THE ROTARY KNIFE IN THE CONTROL OF POTATO RING ROT

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Potato ring rot is most effectively controlled through a three-point program involving: 1) disposal of all potatoes, 2) disinfestation of premises and equipment, and 3) subsequent use of ring-rot-free seed. There are emergencies, however, when this program cannot be followed. The spring of 1943, for instance, saw growers, who were anxious to convert to disease-free seed, unable to obtain seed of any description. Also there were growers, not previously having had the disease, who did succeed in getting some seed, only to find that what they bought was ring-rot infected. About 200 carloads of so-called "Selected" seed were brought into New York State to meet the wartime shortage, and reports showed that many and possibly all of these lots contained ring rot.

To find methods of bringing about some measure of control under emergency situations such as these, a number of experiments were carried out during the summer of 1943, and two of these, which involve principally the use of the rotary cutting knife, constitute the subject of this report.

Rotary knives have previously been proposed and advocated for the control of ring rot (1, 2) but to the writer's knowledge no data have been published on their effectiveness except those reported by Starr (3) on temperature effects. Presented at this time, therefore, are results of the following two factorial experiments. Because of inclusion in the same factorials, results are also given here on the effectiveness of two mercuric chloride seed dips, the ultra violet sorting method, and a test to determine the extent of ring-rot spread due to the use of a picker planter.

Experiment 1 consisted of a factorial design to test the relative efficacies of 1) the rotary knife, 2) a mercuric chloride cut seed dip, and 3) the ultra violet sorting method.

Seed potatoes of the variety Katahdin were employed, which contained approximately 2 per cent macroscopically detectable ring rot. None of the obviously infected tubers was planted. The field plan consisted of four randomized blocks each 100 feet long, with 100 seed pieces planted to the row.

Seed pieces were treated as indicated in the column headings of table 1. All cutting was done with knives that were passed through

TABLE 1. *Summary of data on sprout emergence, vine wilting, and tuber yields.* (*Experiment* 1).

	Treatments								
	U+S+T+*	U+S+T—	U+S—T+	U+S—T—	U—S+T+	U—S+T—	U—S—T+	U—S—T—	Totals
Sprout emergence 8/14/43									
Totals °	304	368	313	374	337	375	331	374	2776
Per cents	76.00	92.00	78.25	93.50	84.25	93.75	82.75	93.50	
Vine wilting 9/21/43									
Totals °	0	4	0	124	0	6	3	142	279
Per cents	0	1.00	0	31.00	0	1.50	0.75	35.50	
Yields, in bu. /acre									
Healthy tubers	157.4	192.3	168.5	158.5	170.0	211.5	175.0	147.5	
Diseased tubers	0.5	1.3	0.0	36.0	0.0	0.8	0.7	44.4	
Total tubers	157.9	193.6	168.5	194.5	170.0	212.3	175.7	191.9	

* U+ = Ultra violet light used to discard all tubers showing greenish fluorescence.
U— = No ultra violet light used.
S+ = Rotary cutting knife used to cut seed pieces.
S— = Non-disinfested knife used to cut seed pieces.
T+ = Treatment for cut seed used, consisting of 1:1000 $HgCl_2$, immersion for 1½ - 2 hours.
T— = No cut-seed treatment used.
° Base = 400.

ring-rot diseased tubers in advance of cutting every five healthy tubers.

Treatment "T+" consisted of dropping seed pieces immediately after cutting into a solution of 1:1000 mercuric chloride, where they were allowed to remain for 1½ to 2 hours. Treatment "T—" was given to an equal number of seed pieces, and differed from "T+" in that no mercuric chloride dip was used.

Treatment "S+" consisted of cutting seed pieces with a rotary knife disinfested by boiling water.* Treatment "S—" differed in that the knife was not run through boiling water; in other words, the knife was not disinfested.

Treatment "U+" consisted of examining stem ends of tubers with an ultra-violet light, discarding those which showed the greenish fluorescence characteristic of ring rot. Treatment "U—" differed from "U+" in that no ultra-violet examination was given the stem-end clipped tubers.

Data on emergence, wilt counts, and tuber yields are presented in table 1. Statistical treatment of these figures by an analysis of variance shows the effects of the treatments and combinations of treatments given in table 2. The effects which are statistically significant have been underscored.

TABLE 2. *Comparison of treatment effects.* (*Experiment* 1).

	Tubers in Bushels per Acre		
Effects	Healthy	Diseased	Healthy & Diseased
MAIN — Increase or decrease due to treatments.			
U*	—6.8	—2.0	—8.9
S*	20.4	—19.6	0.8
T*	—9.7	—20.3	—30.0
INTERACTIONS — Increase or decrease "together" over "separately."			
US	—9.1	2.5	—6.6
UT	—2.7	2.0	—0.7
ST	—28.5	19.5	—9.0
UST	6.0	—1.9	4.1
Least Signif. Diff.	±13.0	±3.9	±12.7

*U = Ultra violet light.
S = Rotary knife.
T = $HgCl_2$ seed treatment.

* Details of the construction of such a knife are available from the Department of Plant Pathology, Cornell University, Ithaca, N. Y.

Inspection of figures in table 2 shows that of the three control methods tested when used separately, only the rotary knife was instrumental in producing a significant increase in the yield of healthy tubers and a significant decrease in the yield of diseased tubers. The mercuric chloride cut-seed treatment also reduced ring rot significantly, but affected detrimentally the yield of healthy tubers. The use of ultra-violet light showed no significant control of ring rot, but this was to be expected because of the technique of inoculation used and because surface contamination by *Corynebacterium sepedonicum* cannot be detected by ultra-violet radiation. The number of replications were too few and/or the difference was too small to show significant differences as a result of using the ultra-violet test.

When the three controls (U, S, and T) were used in various combinations, significant differences were found only when the rotary knife and the cut-seed treatment were used simultaneously. Table 3 shows this significant interaction in detail. From these figures it can be seen that the use of the rotary knife together with the cut-seed treatment

TABLE 3. *Yields of healthy, diseased and total tubers with the various combinations of treatments. (Experiment 1).*

	Tubers in Bushels per Acre		
	Healthy	Diseased	Healthy & Diseased
No treatment and no rotary knife	153.0	40.2	193.2
Treatment ($HgCl_2$) alone	171.8	0.4	172.2
Rotary knife alone	201.9	1.1	203.0
Treatment + rotary knife	163.7	0.3	164.0
Least Signif. Difference	36.8	11.0	36.0

was less effective in producing healthy tubers and a high total yield than when either treatment was used separately. In this comparison the rotary knife alone again showed a significant increase in yield of healthy and total tubers, whereas the mercuric chloride treatment of cut seed alone showed an insignificant increase in healthy tubers and a decrease in total tubers. The decrease in amount of ring-rot diseased tubers when both treatment of cut seed and rotary knife were used together was no greater than when either control was used separately.

TABLE 4. *Analysis of covariance of stand and total yield. Counts and weights based on four 100-foot rows. (Experiment 1).*

Source of Variation	Degrees of Freedom	Sums of Squares and Products			Errors of Estimate		
		Stand	Stand x Yield	Yield	Sum of Squares	Degrees of Freedom	Mean Square
Total	31	2100.00	1721.07	2154.51			
Blocks	3	123.25	97.80	102.78			
Treatments	7	1511.00	1251.12	1207.46			
Error	21	465.75	372.15	844.27	546.91	20	27.35
Treatment + Error	28	1976.75	1623.27	2051.73	718.74	27	
Difference for testing adjusted treatment means					171.82	7	24.55
$F = 24.55/27.35 = 0.8976$			$r_t = 0.9263^{xx}$				

An analysis of covariance (tables 4 and 5) based on data of emergence and total yield shows that there exists a close correlation between the number of plants and the total crop. In other words, whatever reduction in yield was encountered is attributable to the injurious

TABLE 5.—*Analyses of variance of yields and stands. (Experiment* 1).

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F
	ANALYSIS OF VARIANCE OF YIELDS:			
Blocks	3	102.78	34.26	
Treatments	7	1207.46	172.49	4.29xx
Error	21	844.27	40.20	
	ANALYSIS OF VARIANCE OF STANDS:			
Blocks	3	123.25	41.08	
Treatments	7	1511.00	215.86	9.73xxx
Error	21	465.75	22.18	

effect of the particular seed treatment in preventing emergence of shoots. As has been pointed out, most detrimental to emergence was the use of the mercuric chloride seed piece dip. Neither the sterile cutting knife nor the ultra-violet light showed any injurious effect on the number of sprouts emerging.

Experiment 2 consisted of a factorial to test the effectiveness again of the rotary cutting knife and of an acidulated mercuric chloride treatment of cut seed for the control of ring rot spread. In addition the experiment also was designed to show the relative importance of the cutting knife and the picker planter in the spread of this disease.

Potatoes used for this experiment were of the variety Katahdin and at time of cutting contained approximately 15 per cent ring rot as determined by macroscopic examination. Only tubers appearing ring-rot free were used in the experiment, the attempt being made in this way to hold surface spread of ring rot responsible for most or all of the disease occurring in the field. Spread of ring rot on the cutting knife was accomplished as in Experiment 1, that is, by cutting one diseased potato in advance of each 5 healthy ones.

One-half the seed used in this experiment was cut with the rotary cutting knife, and one-half was cut by hand, using a knife which was not disinfested. One-half of each preceding lot in turn was immersed

TABLE 6. *Summary of data on sprout emergence, vine wilting, and tuber yields.* (*Experiment 2*).

	Treatments								
	S+T+P+*	S+T+P—	S+T—P+	S+T—P—	S—T+P+	S—T+P—	S—T—P+	S—T—P—	Totals
Sprout emergence 7/30/44: Totals	217	250	346	365	250	270	366	374	2438
Per cents	54.25	62.50	86.50	91.25	62.50	67.50	91.50	93.50	
Vine wilting 9/17/44 Totals	1	1	28	24	1	1	71	56	183
Per cents	0.25	0.25	7.00	6.00	0.25	0.25	17.75	14.00	
Yields, in bu. /acre Healthy	135.0	146.8	201.8	226.0	154.4	150.2	180.4	214.0	
Diseased	0.6	0.2	6.3	5.1	1.0	0.3	15.3	12.6	
Total	135.6	147.0	208.1	231.1	155.4	150.5	195.7	226.6	

*S+ = Rotary knife used to cut seed pieces.
S— = Non-disinfected knife used to cut seed pieces.
T+ = Treatment for cut seed used consisting of 1:500 HgCl, acidified with 0.2 per cent HCl; immersion for 5 minutes.
T— = No seed dip used.
P+ = Picker planter used.
P— = No picker planter used, *i.e.*, planting was done by hand.

immediately after cutting, for 5 minutes, in a 1:500 mercuric chloride solution acidified with 0.2 per cent hydrochloric acid. To prevent any possible deterioration of the solution, it was changed after the treatment of each 100 seed pieces. All seed pieces were then put in paper bags, taken to the field, and planted.

A picker planter was used to plant the seed designated "P+", and the "P—" seed was planted by hand.

The field plan consisted of randomized blocks, each treatment being replicated 4 times in rows 100 feet long. One hundred seed pieces were planted to the row.

Data on emergence, wilt counts, and tuber yields are presented in table 6, and table 7 gives the data in a comparison of treatment effects.

TABLE 7. *Comparison of treatment effects.* (*Experiment 2*).

Effects	Tubers in Bushels per Acre		
	Healthy	Diseased	Healthy & Diseased
MAIN — Increase or decrease due to treatments.			
T*	—59.0	—9.3	—68.3
P*	—16.4	1.3	—15.1
S*	2.7	—4.3	—1.6
INTERACTIONS — Increase or decrease "together" over "separately."			
TP	12.6	—0.7	11.8
TS	—14.1	4.0	—10.1
PS	—1.6	—0.5	—2.1
STP	—6.4	0.3	—6.1
Least Signif. Difference	±19.5	±2.7	±19.3

*T = $HgCl_2$ seed treatment
P = Picker planter
S = Rotary knife

Inspection of table 7 shows, under main effects, that both the rotary knife and the seed treatment when used separately produced a significant reduction in the amount of ring-rot diseased tubers. As far as the yield of healthy tubers was concerned, however, the sterile knife produced an insignificantly small increase, whereas the seed treatment

brought about a highly significant decrease. The sterile knife, when used alone, gave the highest yield, but not significantly higher than when no sterile knife was used.

The interaction effects of the various treatments were without significance except when the seed treatment and the sterile knife were used together. As amplified in table 8, these two controls used simultaneously caused a significant decrease in total yield below that obtained when no control measures were employed. When used separately, however, sterile knife and seed treatment did reduce significantly the amount of diseased tubers as compared with the use of neither of these controls.

TABLE 8. *Yields of healthy, diseased, and total tubers with the various combinations of treatments. (Experiment 2).*

	Tubers in Bushels per Acre		
	Healthy	Diseased	Healthy & Diseased
No treatment & no rotary knife	197.2	14.0	211.2
Treatment ($HgCl_2$) alone	152.3	0.7	153.0
Rotary knife alone	213.9	5.7	219.6
Treatment + rotary knife	140.9	0.4	141.3
Least Signif. Difference	55.1	7.7	55.0

An analysis of covariance (tables 9 and 10) based on data of stand and total yield, shows the existence of a close correlation between number of plants and total yield, indicating that any decrease in total yield is attributable to the injuriousness of a particular seed treatment. In other words, the decrease in total yield caused by the use of the mercuric chloride seed dip was due to the injurious effect of this compound on sprout emergence.

To what extent does the picker planter spread ring rot relative to the contaminated cutting knife? Table 7 shows that when the picker planter was used there was an increase of 1.3 bushels of diseased potatoes per acre in comparison with the yield where no picker planter was used. The increase, however, is statistically insignificant. When a contaminated knife was used, the increase in diseased potatoes was 4.3

TABLE 9. *Analysis of covariance on stand and total yield. Counts and weights based on four 100-foot rows. (Experiment 2).*

Source of Variation	Degrees of Freedom	Sums of Squares and Products			Errors of Estimate		
		Stand	Stand× Yield	Yield	Sum of Squares	Degrees of Freedom	Mean Square
Total	31	8,728.87	7,061.29	8,421.65			
Blocks	3	569.62	667.79	912.21			
Treatments	7	7,195.37	6,053.52	5,566.19			
Error	21	963.88	339.98	1,943.25	1,823.33	20	91.17
Treatment + Error	28	8,159.25	6,393.50	7,509.44	2,499.56	27	
Difference for testing adjusted treatment means					676.23	7	96.60

$F = 96.60/91.17 = 1.6$ $r_t = 0.9565^{xx}$

TABLE 10. *Analyses of variance of yields and stands.* (*Experiment* 2).

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F
	ANALYSIS OF VARIANCE OF YIELDS:			
Blocks	3	912.21	304.07	3.29
Treatments	7	5,566.19	795.17	8.59xxx
Error	21	1,943.25	92.54	
	ANALYSIS OF VARIANCE OF STANDS:			
Blocks	3	569.62	189.87	4.44
Treatments	7	7,195.37	1,027.91	22.39xxx
Error	21	963.88	45.90	

bushels per acre (cf. 19.6 bushels under Experiment 1) as compared with the yield obtained by using a rotary knife. This is a significant difference and indicates that under the conditions of this experiment the cutting knife is much more important in the spread of ring rot than is the picker planter.

SUMMARY

Two factorial experiments in the control of ring-rot spread were carried out to test the effectiveness of 1) the rotary cutting knife, 2) two mercuric chloride cut seed dips, and (3) the ultra violet light.

In both experiments the rotary knife produced higher yields of both healthy and total tubers than any of the other treatments tried. It also led to a statistically significant reduction in the amount of ring-rot diseased tubers.

In both experiments mercuric chloride seed piece dips gave the greatest control of ring-rot spread, but at the same time led to the smallest crop of healthy and of total tubers.

Either the extent of the field layout or the differences obtained, or both, were too small to show results of statistical significance in the control of ring-rot by the use of the ultra violet light.

Analyses of covariance showed a high correlation between stand and yield, indicating that the yield of total tubers (healthy + diseased) was dependent on the effect of the particular treatment on emergence.

The picker planter in the field led to an apparent spread of ring-

rot, but the increase under conditions of the experiment may have been due to random variations as the difference was not statistically significant.

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SECTIONAL NOTES

CALIFORNIA

We will produce an estimated total of 53,200 acres of Irish potatoes in Kern County in 1944. We are now in the midst of harvesting the mountain crop which consists of approximately 3,000 acres. A portion of this mountain crop, of course, is to be used for seed.

During the harvesting of the crop in the floor of the valley during the months of April, May, June, and July we found that the quality of seed that had been purchased to produce this crop, in many cases, was very low. The principal problems we experienced were those of ring rot and a combination of mosaic diseases. The State Department of Agriculture that is certifying seed at the present time for the 1945 crop is bearing down on seed production this year and attempting to secure a higher quality of seed. We, in Agricultural Extension Service work, are encouraging growers to make sure, when purchasing seed, that it is free from ring rot and as free as possible from mosaic disease problems.

We have heard many estimates regarding the acreage of the 1945 crop. The general feeling at the present time seems to be that the acreage will be about the same, if not larger, in 1945 than it was in 1944. Growers who received a poor quality seed this year have suffered, in many instances, a severe loss while growers whose potatoes were of high quality seed generally made a fair return. (Sept. 7).—M. A. Lindsay.

COLORADO

During the past two or three years, the importance of the intermediate potato crop in Colorado, has been rapidly increasing. To date (Sept. 10) shipments are 1,000 cars ahead of the same date last year, and comprise about 25 to 30 per cent of the total shipments for the season.

The frost which occurred in the San Luis Valley during the latter part of August is estimated to have reduced the yields in that area 10 to 20 per cent. The varieties for early shipment consisting of Triumph, Cobbler and White Rose were only slightly reduced in yield and the chief damage occurred on the Red McClure crop.

The season continues cool and except for extreme dryness is very favorable to potato production. Our supplies of irrigation water are adequate, but the small amount of dry land acreage would be greatly benefited by rainfall.

It looks as though there would be another increase in the production of certified seed and prospects are for a crop of exceptionally high quality. Plans are being made to enlarge the indexing program and supplementing the 25,000 tuber greenhouse indexing with a 50,000 tuber field indexing program, located in some winter crop producing-state, probably California. (Sept. 13).—C. H. Metzger.

CONNECTICUT

This season the weather has again been generally unfavorable for potatoes in Connecticut. The average precipitation in July was 2.16 inches, 54 per cent of normal; and in August was 2.04 inches, 49 per cent of normal. This means a serious reduction in yields. (Sept. 6).—B. A. Brown.

IDAHO

The opinion, generally, in Idaho is that there will be a light crop of Russet Burbanks. Many fields are maturing early even in cases of late planting and some are mature enough for digging to begin. Differences in fertility, particularly in proper rotations where alfalfa precedes potatoes, are showing up wide differences in maturity. An extremely wet planting season, considerable rhizoctonia and black leg injury may also be contributing factors. Fields also have not received the careful attention that has been given to watering as in years of more normal labor conditions. The quality observed in many fields has been very good,—with the majority of the tubers being fairly small.

Our growing season in the high altitude seed sections has been longer than last year and with a few exceptions most of this area has escaped summer frosts. With increased acreage, Idaho should have a large quantity of seed available for the 1945 planting.

Our growers are concerned over the labor situation, but look for prices to be maintained close to the ceiling. (Sept. 11).—Eugene W. Whitman.

INDIANA

Late rains have somewhat revived the hopes of getting a few potatoes in Indiana, but even when I state that the crop is going to be exceptionally short, there is no one who seems to be seriously worried. A few potatoes are moving in the northern counties, particularly from the muck, and these are mainly of the Cobbler variety. Although the late-maturing varieties are still rather green there is only about one-half a stand.

If the price of certified seed is high again next spring, I presume that it will somewhat reflect upon the purchases of Indiana growers who will be needing a large supply of certified seed again for the 1945 planting.

The potato bugs and leafhoppers have been desperately in need of good food for the past month and have had to find this nutriment from some other plant besides potatoes. (Sept. 2).—W. B. WARD.

KENTUCKY

Because of the hot weather and dry soil at planting time, some stands are as low as 33 per cent, although other growers, in sections where chance rains fell, have stands that lack only 5 per cent of being full.

The fall rains started almost a month earlier than normal, and the plants that have come up are doing extraordinarily well. It is our opinion that if no more rain falls, the crop will still be satisfactory and the scattered stands (unless too scattered) should still yield about what we ordinarily expect of our "second crop" potatoes, 12 to 1. (Sept. 5). —JOHN S. GARDNER.

MINNESOTA

Minnesota potato growers are harvesting considerably less acreage than was harvested in 1943, largely because of water damage in certain areas of the state. In 1943, 243,000 acres producing 23,571,000 bushels were harvested, whereas the last report indicates 209,000 acres to be harvested with an estimated production of 17,765,000 bushels. When the final figures are summarized the acres to be harvested will be less than the acreage now estimated. The yield is not so large as it was last year.

All the potatoes in the sand land area have been disposed of at this time,—at ceiling or near ceiling prices. Digging in the Red River Valley

started about the middle of August, but was halted by torrential rains which made digging impossible for about a week. Since these rains, the weather has cleared and harvesting conditions have been excellent. (The last week of August and the first week of September). About twice as many cars of potatoes have been shipped to date as were shipped last year at this time,—all at approximately ceiling prices.

We haven't as yet compiled the figures on certified seed potato production in the state, but there will be about 25,000 acres. The yield will be somewhat smaller than it was last year and it is doubtful that we will have a great deal more certified stock than we had in 1943. Some early Triumph certified seed has already been shipped.

This year some of our certified seed growers have built additional modern track-side storages. Most of the larger producers of certified seed are now well equipped with such storages. These storage houses are a distinct advantage in many ways. (Sept. 10).—A. G. Tolaas.

NEBRASKA

The Nebraska situation has improved since last month. The drought and heat during the early part of August has checked the dry land fields, which were so favorably situated earlier in the season. Good rains were received over most of the territory during the last week of August. These rains, in addition to cool weather, will mean favorable conditions for the final development of the crop.

Early Blight is developing in many parts of the territory during the wet period, but seems to have been checked in most places by the resumption of warm clear weather. Only an occasional field has gone down with Early Blight, and is beyond recovery.

Since the average date of killing frost in the western high plains area occurs about the 25th of September, no accurate estimate of yield prospects can be given now. Given frost-free weather for another two or three weeks, and barring further Early Blight encroachments, our dry land yields should reach an average of 125 bushels, and the irrigated about double that amount. It should be emphasized that this is strictly an estimate, based on good growing conditions for most of September. Since no harvesting takes place until about the first of October, in the Nebraska main crop, no prices have been established. This applies to commercial as well as to certified seed.

Our final field inspections on certified seed potatoes have been made. Following harvest, the bin inspections will be made prior to grading and shipment during the winter months. The total acreage

entered for certification, including all varieties, was approximately 9,800 acres. With the exception of three per cent of this acreage the remainder is of the Bliss Triumph variety. Other varieties now entered for certification include Kasota, Red Warba, Katahdin, Cobbler, Russet Rural and White Rose. (Sept. 7).—MARX KOEHNKE.

NEW JERSEY

Approximately 90 per cent of our crop is now harvested. Our yields have been slightly better in some areas than previously anticipated. However, the average yield as of the 1st of September was estimated at 123 bushels per acre. This is the lowest yield on record for New Jersey since 1925, therefore, most of our growers have not had a very successful year,—financially.

The growers who practiced a system of rotation noticed that higher yields were produced on the rotated areas than on fields that have been constantly in potatoes. Their practice of incorporating some organic matter in the soil paid dividends this year.

The acreage of seed potatoes entered for certification this year totaled 475 acres,—a reduction of 365 acres compared with last year's entry. The drought has greatly retarded growth and on the 1st of September the condition was reported to be 61 per cent of normal. The heavy rains from Sept. 12-14 have provided sufficient moisture to insure good growth for the next two or three weeks and therefore yields should be considerably higher than estimated on the 1st of September. (Sept. 18).—J. C. CAMPBELL.

NEW YORK

The drought is still unbroken in Suffolk Co. Because of the dry weather many Green Mountain potato vines which are normally dead by the 15th of August are still green. Quite a percentage of tubers have started to grow in the ground.

Our early varieties have yielded about two-thirds of a normal crop. Green Mountains are also yielding, on the average, only one-third of normal. Naturally they are a small average size. However, because of the light set they are larger in size than they would have been had the set been a heavy one. Harvesting is well along for this time of the year. On account of the dry weather our cover crops will be planted later than usual. (Sept. 8).—H. R. TALMAGE.

Since reporting conditions as of early August, the potato crop situation in New York has become worse rather than better. No gen-

eral, beneficial rains have occurred in any important potato section of New York since late June.

Long Island growers report fair yields of early varieties but the late main crop of Green Mountains is running 75 to 80 bushels per acre. This is no more than one-third of the normal yield. Muck growers are in the most favored position for they are reporting not only a fair yield but a yield of good quality. However, only about 9,000 acres are grown on muck. This represents only about 4 per cent of the state's total acreage and 10 per cent of the total production this year. Among the few upstate growers who have harvested, the average size of the tuber is running even smaller than expected. It is too late for rain to recoup losses except perhaps in late-planted fields with the late varieties such as Rural, Russet Rural and Green Mountain which continue to grow in size late in the season.

Late blight reported generally in July was pretty thoroughly checked by the dry weather and heat of July and early August. Cool nights and heavy dews finally came in early September, which combination may result in a resumption of spread in the poorly sprayed fields.

The further upward adjustment in potato ceiling prices through September should give considerable encouragement and some financial help to growers whose yield and tuber-size are both subnormal this year. (Sept. 12).—E. V. Hardenburg.

OREGON

Our final field inspection of certified seed was completed during the last week in August. More than 1,400 acres passed all field tests. The quality is good and indications are that our yield will be about average.

Damaging frost occurred on the morning of the 2d of September. Fifty to 75 per cent of the vines were frozen down in many fields. Our anticipated yields will undoubtedly be decreased. Earlier digging may result, with better distribution of labor. Heavy digging and shipping are now getting under way (September 5th). (Sept. 6).—C. A. Henderson.

VERMONT

Dry weather, accompanied by record heat and sun glare, caused premature ripening of plants. No very accurate estimate of loss in yield can yet be made. It will, however, be an important factor, particularly in plantings made late in May and in June. Our early plantings ap-

parently got off to a good start and therefore were less affected by the weather.

The main crop is still Green Mountains with a considerable pick up in Katahdins and Houmas. Katahdins seemed to go down before the heat earlier than did the Green Mountains. The few Sebagoes and Sequoias were naturally outliving the intermediate season varieties. Very few Cobblers or other early varieties are now planted in Vermont.

Seven hundred and seventy-four acres were entered for seed inspection according to revised and final compilation. With the exception of 50 acres all our potatoes have passed field inspections barring any possible findings of ring rot at harvesting.

Thus far only one plant of bacterial ring rot has been found in any field entered for certification. This probably was a volunteer. A few plants have been found in table stock fields planted with seed known to have been infected for several years. No serious loss was yet noticeable. (Sept. 14).—H. L. Bailey.

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RESULTS OF POTATO VARIETY TESTS AT HASTINGS, FLORIDA

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Within the past 15 years many new potato varieties have been produced as a result of the cooperative potato-breeding work of the United States Department of Agriculture and several states. After new varieties are found to be superior to standard ones in yield, quality, or resistance to one or more diseases at the various testing stations, they are sent to different commercial potato-growing sections of the United States where they are compared with varieties commonly grown in those sections.

Twelve of the new varieties and 5 old varieties have been tested for adaptability and yield at the Potato Laboratory, Hastings, Florida, during the last 7 years and the results are reported in this paper.

Growing Conditions

Potato varieties that produce good yields in one section of the country often fail to yield as much in other sections where weather conditions are not so favorable for potato growth, and insects and diseases are more destructive (2, 3). Potatoes grown in the sandy soils of the Hastings Section, Florida, seldom yield more than 300 bushels per acre even on the best managed farms during seasons most favorable for the growth

[1] Plant Pathologist and Horticulturist, respectively.
[2] Senior Geneticist.

of the crop. The annual commercial yield for the 7-year period, 1938-1944, has averaged only 141 bushels per acre (table 1). The low yields in 6 of the 7 years were due principally to adverse weather conditions and to the presence of late blight and other destructive diseases (1).

TABLE 1. *Relation of weather and diseases to yields produced in commercial potato fields at Hastings, Florida, from 1938 to 1944.**

Year	Freezes in February or March	Rainfall in Inches		Loss from Diseases	Average Yield Per Acre
		March	April		
				Per cent	Bushels
1938		1.77	1.25	16.5	126
1939	X	0.66***	2.11	11.0	123
1940		1.89	2.24	6.0	220
1941	X	2.26	3.55	7.7	110
1942		8.90**	0.28***	6.2	160
1943	X	2.89	2.04	6.1	125
1944		9.12**	5.56**	26.5	125
Average		3.93	2.43	11.4	141

* Data on frost, rainfall and yield obtained from the U.S. Weather Bureau and Bureau of Agricultural Economics.
** Very wet.
*** Very dry.

During the 7 years the variety tests were conducted at Hastings, injury from freezes caused severe reductions in yields of potatoes in 1939, 1941 and 1943. Drought in March or April of 1939 and 1942 cut the yield in those 2 years and excessive rainfall in March and April, 1944 damaged the crop severely. The seed-borne diseases caused severe losses in 1938 when rugose mosaic, leafroll and ring rot accounted for 7 per cent of the 16.5 per cent loss reported for that year, but the greatest damage from diseases occurred in 1944 when 15 per cent of the crop was destroyed by late blight and 10 per cent by bacterial soft rot.

RESULTS OF YIELD TESTS

The varieties listed in table 2 were tested for yields on different farms from 1 to 7 years. They were grown in Bladen fine sand and fine sandy loam soils which had been fertilized with 1 ton of a 5-7-5 commercial fertilizer per acre at planting time. The potatoes were planted in December or January and were harvested in April or May during the different years.

TABLE 2. *Yields of U. S. No. 1 potatoes of different varieties grown in test plots at Hastings, Florida, during the 7-year period 1938 to 1944.*

Variety*	Bushels per Acre							
	1938		1939			1940		
	Farm E	Farm G	Farm E	Farm G	Farm L	Farm E	Farm G	Farm L
Katahdin	267	100	181	273	303	229	237	295
Sebago	295	159	238	386	358	288	297	405
Pontiac	267	—	251	422	—	260	310	365
Chippewa	226	54	147	314	—	163	229	271
Earlaine	—	—	119	—	179	33	129	—
Warba	202	86	184	367	—	—	—	294
Red Warba	—	—	182	391	—	197	252	—
Sequoia	—	—	—	—	—	—	—	423
White Rose	237	—	79	261	—	272	266	266
Spaulding Rose	177	74	190	300	179	203	241	253
Irish Cobbler	263	153	139	224	—	249	266	245
Bliss Triumph	210	135	114	293	—	201	230	245
Green Mountain	247	91	143	231	—	—	—	—
Mesaba	—	—	84	179	—	—	—	—
Houma	—	—	—	—	—	—	—	—
Mohawk	—	—	—	—	—	—	—	—
Pawnee	—	—	—	—	—	—	—	—
Difference Required for Significance (19:1)	47	50	44	51	58	33	33	50

TABLE 2. *Yields of U. S. No. 1 potatoes of different varieties grown in test plots at Hastings, Florida, during the 7-year period 1938 to 1944*—(Continued).

Variety*	Bushels per Acre								
	1941		1942			1943		1944	Average Yield
	Farm E	Farm L	Farm E	Farm P	Farm L	Farm E	Farm L	Farm E	
Katahdin	146	145	180	222	195	208	255	75	207
Sebago	201	213	239	240	302	255	320	177	273
Pontiac	209	237	295	311	296	154	—	157	272
Chippewa	97	112	172	—	—	38	—	105	165
Earlaine	109	140	208	269	269	—	—	104	156
Warba	—	—	—	—	—	—	—	—	227
Red Warba	122	174	250	—	—	—	—	—	224
Sequoia	212	220	288	286	349	297	346	156	286
White Rose	—	—	—	—	—	—	—	—	230
Spaulding Rose	170	120	195	—	207	—	—	—	192
Irish Cobbler	176	162	186	—	—	172	—	—	203
Bliss Triumph	84	79	202	—	—	70	—	71	161
Green Mountain	—	—	—	—	—	—	—	—	178
Mesaba	—	—	—	227	—	—	—	—	227
Houma	—	—	—	—	—	180	213	72	155
Mohawk	—	—	—	—	—	—	—	75	75
Pawnee	—	—	—	—	—	—	—	120	120
Difference Required for Significance (19:1)	22	25	27	24	29	21	38	19	

* Each grown in 25-foot single-row plots 39 to 40 inches apart, replicated 5 to 6 times in a random arrangement in 1938 and 1939 and in Latin square plots of the same size from 1940 to 1944, inclusive.

Seventeen varieties were grown in the test plots during the 7-year period but Katahdin and Sebago were the only ones grown every year on each farm. Some were eliminated after they had been tested 2 or more years and proved inferior in yield or quality to Katahdin, and others were added to the test when seed became available for planting them.

Sequoia, Sebago and Pontiac produced the best yields and each one of these varieties significantly outyielded each of the other varieties nearly every year on most of the farms.

Table 3 shows the average yield of each variety and the percentage increase or decrease in comparison with yields of Katahdin in the same tests. It includes only those that were grown for 2 or more years in three or more test plots. Sequoia yielded 50 per cent more than Katahdin, whereas the increase in yield of Sebago and Pontiac over Katahdin amounted to 32 per cent and 33 per cent, respectively. The yields of Red Warba and Warba exceeded the yields of Katahdin slightly, but the remaining nine varieties yielded less. The yield of Mesaba, which was the lowest of all, was 29 per cent less than that of Katahdin.

Characteristics of Different Varieties

Some of the characteristics of 5 old and 10 new potato varieties tested for yield at Hastings for 2 or more years are summarized in table 4.

The most important characteristics which determine whether or not a variety can be grown profitably year after year at Hastings are: First, the ability to recover and produce a yield after the tops of the plants are killed by freezes during the early stages of growth, since such freezes occur about once in 2 years; and second, the ability to produce marketable tubers of U. S. No. 1 grade during dry seasons (1). Only four varieties, Sebago, Sequoia, Pontiac, and Katahdin, listed in table 4, made good recovery from freezing injury and have good resistance to drought. Three of these, Sebago, Sequoia and Pontiac, have also produced the best yields at Hastings.

Some of the other varieties have produced excellent yields of high quality tubers during seasons most favorable for potato growth, but under less favorable growing conditions they have yielded poorly and have produced a high percentage of cull tubers. This has been particularly true of Earlaine, Spaulding Rose and White Rose which are subject to second growth and have produced a high percentage of tubers with knobs during seasons when the rainfall has been unevenly distributed (2).

TABLE 3. *Comparison of average yields of U. S. No. 1 tubers per acre of Katahdin and other varieties of potatoes grown at Hastings, Florida, from 2 to 7 years.*

Variety	Number Years Tested	Number of Tests	Average Yield	Average Yield of Katahdin	Yield Compared with Katahdin	
					Increase	Decrease
			Bushels	Bushels	Per cent	Per cent
Sebago	7	16	273	207	32	
Pontiac	7	13	272	204	33	
Chippewa	7	12	165	195		15
Bliss Triumph	7	12	161	195		17
Irish Cobbler	6	11	203	205		1
Sequoia	5	9	286	191	50	
Spaulding Rose	5	12	192	212		9
Earlaine	5	10	156	191		18
Red Warba	4	7	224	199	13	
Warba	3	5	227	223	2	
White Rose	3	6	230	247		7
Green Mountain	2	4	178	205		13
Houma	2	3	155	179		14
Mesaba	2	3	163	228		29

TABLE 4. *Some characteristics of 15 varieties of*

TABLE 4. *Some characteristics of 15 varieties of potatoes grown at Hastings, Florida.*

Variety	Growing Period	Recovery of Plants from Freezing Injury*	Resistance to Drought	Objectionable Characteristics of Tubers
Sebago	Very late	Good	Good	Lenticels become very conspicuous on tubers in wet seasons.
Sequoia		"	"	Patches of russet skin on tubers. Tubers not shaped uniformly.
Green Mountain	Late	Poor	Poor	None
Houma		"	"	"
Katahdin		Good	Good	"
Pontiac		"	"	Skin of tubers too light a shade of red; not as attractive as Bliss.
Irish Cobbler	Medium early	Poor	Poor	None
Mesaba		"	"	"
Spaulding Rose		Good	"	Subject to second growth, forms knobs. Skin too dark for a white potato.
White Rose		Poor	"	Subject to second growth, forms knobs. Tubers not shaped uniformly.
Bliss Triumph		Very Poor	Very Poor	None
Chippewa	Early	" "	" "	"
Earlaine		" "	" "	Subject to second growth, forms knobs.
Red Warba		Poor	Poor	Deep eyes, splashes of white on tubers which are not shaped uniformly.
Warba		"	"	Deep and pink eyes. Tubers not shaped uniformily.

* When tops are killed during early stages of growth before plants have produced U. S. No. 2 tubers.

Tubers of all varieties, particularly those with white skins, turn green very soon on exposure to sunlight in Florida. To avoid excessive losses from greening, the plants are usually kept well ridged to prevent the tubers from growing out of the ground and turning green, particularly the Katahdin which forms long stolons and sets its tubers high.

Observations have been made on the reaction of some of the varieties to the five most common and destructive diseases of potatoes at Hastings.

None of the 17 varieties listed in table 2 has shown any resistance to late blight (*Phytophthora infestans* (Mont.) De By.). In 1944, plants of the Sebago variety, which have been reported as resistant to this disease, were killed by it in almost all commercial potato fields.

During seasons when weather and soil conditions have favored its development, bacterial soft rot (*Erwinia carotovora* (Jones) S. A. B.) has caused severe losses in fields planted in Bliss Triumph, Earlaine, Green Mountain, Irish Cobbler, Katahdin, Pontiac, Sebago and Spaulding Rose.

Blackleg (*Erwinia carotovora* (Jones) S. A. B.) has caused greater losses in commercial fields of Sebago than in those planted to Spaulding Rose, Bliss Triumph or Katahdin.

Katahdin, Green Mountain and Sebago have shown some resistance to brown rot (*Bacterium solanacearum* E. F. S.) when grown in infested soil. Varieties that have proved very susceptible are Bliss Triumph, Chippewa, Houma, Irish Cobbler, Pontiac, Spaulding Rose, Warba and White Rose.

Most of the plants of Katahdin and Sebago whose stems and roots have been attacked by rhizoctonia canker (*Corticium solani* (Prill. and Delacr.) (Bourd. and Galz.) in the early stages of growth have recovered and produced marketable tubers, whereas similarly affected plants of the Spaulding Rose, Irish Cobbler, Bliss Triumph and Warba have not resisted the disease so well and often have produced numerous small tubers and aerial tubers.

Conclusions

The three new potato varieties, Sebago, Sequoia and Pontiac which have proved to be more resistant to freezing injury in the early stages of growth and more drought resistant than eleven other varieties, have produced the best yields in test plots at Hastings, Florida, during the past 7 years. Sebago and Pontiac yielded about one-third more U. S. No. 1 tubers per acre than Katahdin whereas Sequoia exceeded the yield of the latter by 50 per cent.

Within the past 7 years, Sebago and Katahdin have supplanted the old standard variety, Spaulding Rose, and have become the leading varieties at Hastings. During the past season 65 per cent of the acreage was planted to Sebago and 28 per cent to Katahdin.

Pontiac probably will never be grown very extensively in the Hastings Section since white-skinned varieties have always been the leading ones grown there, and markets have been developed for Hastings-grown potatoes of that color. However, Pontiac may replace Bliss Triumph and become a leading red variety in other potato-growing sections of the state.

The color, shape and uniformity of the tubers of any variety generally determine its salability. If the Sequoia is not discriminated against because of the russet patches on the skin of the tubers and the slight variations in the shape of the tubers, it should soon become the leading variety at Hastings because of its superior yielding ability.

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THE EFFECT OF LATENT MOSAIC (VIRUS X) ON YIELD OF POTATOES IN MAINE

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Latent mosaic, so called because it is carried by Green Mountain and certain other potato varieties without producing conspicuous symptoms, is harbored more generally by most of the old and some of the new potato varieties than any of the other potato viruses. Although an occasional tuber free from latent mosaic (virus X) has been found among some of the old varieties, healthy tubers free from latent mosaic have not been found in tests with thousands of Green Mountain tubers from several potato regions. In the case of many varieties it is practically impossible to diagnose latent mosaic plants in the field. Notwithstanding the general latent mosaic infection in these varieties, they are healthy by commercial standards, but the stocks are diseased according to scientific standards. The general distribution of latent mosaic in potatoes suggests the importance of information about its effect on yield.

Bald and Norris (1) found that in Australia latent mosaic in President and Up-to-Date varieties reduced the yield about 30 per cent and that it is one of the chief causes of the reduction in yield of potatoes in Australia, but, because its effects are evenly spread almost over the entire crop, it passes unnoticed.

Scott (5) reported that in Scotland latent mosaic (virus X) was responsible for yield reductions of 16 to 25 per cent, and that similar yield losses resulted from virus A.

Experimental Procedure

For comparative studies healthy as well as latent-mosaic-infected tubers of Chippewa, Katahdin, and a seedling selection of Green Mountain parentage were used. Two strains of Green Mountain, one har-

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[2] Associate Plant Pathologist.

boring weak virus X and the other common virus X, were used to determine the effect on yield of these two virus X strains.

The Green Mountain seedling selection originated from open-pollinated seed and is practically identical with the commercial Green Mountain variety in foliage characters and in susceptibility and reaction to virus diseases. It contracts latent mosaic readily by foliage contact and manifests common latent mosaic by light green foliage. The Chippewa variety also becomes readily infected with latent mosaic by foliage contact and manifests this disease by light green and mottled leaves. Katahdin rarely contracts latent mosaic in the field, so artificial inoculations were made to obtain diseased stock for the yield tests. Katahdin manifests common latent mosaic by light green and slightly rolled leaves. Since no Green Mountain free from the virus is available, two stocks of Green Mountain were used, one harboring a weak strain of virus X, the other the common virus X. The Green Mountain strain harboring weak virus X was obtained from Vermont, and that infected with common virus X was from Maine.

With the exception of the Green Mountain stock that was infected with the weak strain of virus X, the varieties used in the yield tests harbored the common strain of virus X that is present in many commercial potato varieties.

Weak virus X is so called because it infects Jimson weed (*Datura stramonium*) without producing symptoms, whereas common virus X induces distinct mottling, or a typical mosaic. Jimson weed, when harboring weak virus X, is protected against infection with stronger strains of virus X.

The healthy and the virus infected stocks were propagated in isolated plots to provide seed potatoes for the yield tests in 1939 at Aroostook Farm, Presque Isle, Maine.

Diseased and healthy tubers were cut into 1-ounce seed pieces which were planted 14 inches apart in rows 3 feet apart. At least fifty four-hill replicates were used for each of the diseased and healthy lots in a variety. The replicates were planted so that a diseased one alternated with a healthy one in the same row, as well as between rows. To prevent contact infection, a hill of a variety immune from latent mosaic was planted between the mosaic and healthy replicates. To test for virus X, inoculations were made to Jimson weed and pepper (*Capsicum* sp.) from representative leaves of the healthy plants.

At the end of the growing season, during the last week in September, the potatoes were harvested and weighed.

Results

The results recorded in table 1 disclose that latent mosaic in Chippewa reduced the yield 13 to 14 per cent and in Katahdin 12 to 22 pre cent; the latent-mosaic infected Green Mountain seedling selection yielded 9 per cent less than the healthy; and the weak-latent-mosaic Green Mountain outyielded the common-latent-mosaic Green Mountain by 9 to 10 per cent.

Similar yield tests conducted in 1937, 1938, and 1940 at Aroostook Farm gave about the same results as those obtained in 1939.

Latent mosaic in Katahdin, which rarely contracts this disease in the field, depressed the yield somewhat more than in the other varieties tested. The reduction in yield is influenced by the strain of virus X, as the Green Mountain with weak virus X yielded more than Green Mountain harboring common virus X.

Although thousands of tubers representing Green Mountain stocks from different localities in the New England States and Canada have been tested, no plants free from latent mosaic have been found in this variety, so it has been impossible to compare yields between healthy and latent-mosaic-infected plants of this variety. However, the Green Mountain seedling selection used in the latent mosaic yield tests closely resembles the Green Mountain.

Experience has shown (2, 3) that on Aroostook Farm mild mosaic caused by viruses A + X reduces the yield about 25 per cent.

Yield tests with virus A in seedling selection 41956, which is immune from virus X, showed that in this selection virus A reduced the yield 28 per cent, or about the same as viruses A + X in the Green Mountain seedling. Since virus X in Katahdin reduced the yield as much as 22 per cent, it is possible that in some varieties virus X, especially when represented by the more severe strains of this virus, is responsible for as great losses in yield as those from virus A.

Inasmuch as the comparative yield tests show that latent mosaic is responsible for 10 to 20 per cent reduction in yield and that this mosaic is generally harbored by most of the old potato varieties and some of the new varieties, it is evident that latent mosaic when occurring alone is responsible in this country for annual losses in yield of some millions of bushels. Furthermore, because latent mosaic in combination with other viruses affects the potato more adversely than when alone, additional yield losses of millions of bushels result from virus X in such mixed infections.

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TABLE 1. *Effect of latent mosaic (virus X) on yield of potato. Aroostook Farm, Presque Isle, Maine,* 1939.

Variety	Yield per Acre: Healthy	Yield per Acre: Diseased	Reduction	Odds
	Bushels	Bushels	Per cent	
Chippewa	476 ± 8.36	414 ± 7.23	13	19,230:1
Do	472 ± 9.29	409 ± 9.00	13	825:1
Do	469 ± 8.52	401 ± 7.09	14	19,230:1
Katahdin	315 ± 4.17	277 ± 4.12	12	19,230:1
Do	324 ± 6.10	270 ± 4.25	16	434,782:1
Do	366 ± 6.18	286 ± 6.26	22	M[3] :1
Green Mountain	445 ± 7.73[1]	395 ± 7.31[2]	10	656:1
Do	444 ± 5.62[1]	403 ± 5.63[2]	9	1,350:1
Green Mountain Seedling	415 ± 6.32	376 ± 6.24	9	174:1

[1] Harboring weak latent mosaic.
[2] Harboring common latent mosaic.
[3] M=A million or more.

Control

Procedures for controlling latent mosaic involve (1) propagation of healthy seed stocks in isolated tuber-unit seed plots, (2) protective inoculation of very susceptible varieties with the weak virus X strain, and (3) breeding varieties immune from virus X.

Isolated seed plots

To prevent infection the healthy seed potatoes must be grown in isolated fields, because susceptible varieties contract latent mosaic by foliage contact with diseased plants. Since 1930, or for 14 years, the Green Mountain seedling selection, which is very easily infected with virus X, has been maintained free from this virus on isolated seed plots. By growing test samples of this seedling selection in contact with latent mosaic potatoes, it has been found that during one season 30 to 40 per cent of the plants contracted this disease.

Protective inoculation

The Green Mountain harboring weak virus X has been grown for 10 seasons in alternate hills with Green Mountain carrying common virus X without contracting this common strain. Likewise in exposure tests for several years stocks of the Chippewa variety that were artificially inoculated with weak virus X have not contracted stronger strains of this virus. Thus plants harboring a weak strain of virus X are immune from stronger strains of this virus. This experience shows that the more serious yield losses can probably be prevented by inoculating varieties very susceptible to virus X with a weak strain of virus X to protect them against infection with more severe strains of this virus.

Immunity from virus X

Potato varieties differ in resistance to virus X. Some varieties contract infection very easily, others rarely become infected, and some are immune from virus X. Inasmuch as most of the new varieties obtained by using virus X immune parents in crosses are also virus X immune (4), it is possible to produce immune varieties that possess other desirable characters. Such virus X immune varieties will then greatly facilitate the control of latent mosaic.

Summary

Latent mosaic caused by virus X is harbored more generally than any other virus disease by most of the old and some of the new potato varieties. This disease is harbored by some varieties without producing symptoms, whereas in other varieties it appears as a typical mosaic.

Latent mosaic is caused by several strains of virus X, which are distinguished by the severity of the host reaction. In addition to causing more severe foliage symptoms, the stronger virus X strains depress the yield more than the weak strain.

It is shown that latent mosaic reduces the yield by 9 to 22 per cent, that the yield is depressed more in some varieties than in others, and that annual losses amounting to millions of bushels result from this disease.

Control measures are indicated involving propagation of seed potatoes on isolated fields, protective inoculation with a weak strain of the virus and the development of varieties immune from latent mosaic.

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POTATO WART IN AMERICA

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From the time that potato wart *Synchytrium endobioticum* (Schilb. Perc.) was first found in the United States it has been considered a menace to potato production in this country. At that time it was prevalent in the principal potato-growing countries of Europe. It was reported from Hungary, Germany, France, Italy, Scandinavia, and the British Isles. Severe tolls occurred in many potato fields of Europe,

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[2] Assistant plant breeder.

and the disease was considered one of the most serious by most English authorities (3). In 1909 this disease was reported from Newfoundland (2), and soon thereafter the State and Federal authorities in the United States took precautionary measures to exclude it from this country. In 1912 the Federal Horticultural Board put a quarantine on importation of potatoes from Europe and other areas where this disease was prevalent, but the disease evidently had arrived the preceding year when several million bushels of seed potatoes had been imported from Europe.

In 1918, J. G. Sanders, Pennsylvania Department of Agriculture (3), found potato wart at Highland, Pennsylvania. A survey showed that the disease was scattered over an area including 27 cities and villages in Luzerne, Schuylkill, and Carbon Counties. In some villages only a few gardens were infested with the organism, whereas in other places the disease was found in as many as fifty gardens. In some gardens the attack was not severe, and in others the crop was destroyed.

That potato wart is still confined to the very small area from which it was first reported is due to the strict regulations that have been applied to the importation of foreign potatoes, as well as those governing the growing of potatoes in the infested areas. The finding of immunity in some well-known varieties has also helped very much in the control of this disease. Its establishment is supposedly controlled by temperature and moisture relationships. There are large areas in the United States with a climate similar to that of the districts of Pennsylvania, Maryland, and West Virginia in which wart has already been found, and unless precautions are continued the disease could be spread to other sections.

The wide occurrence of this disease in Europe gave impetus to breeding immune varieties (5), as this seems to be the best method of control. Fortunately a relatively large number of the current varieties in Europe and in the United States were found to be immune to the physiological races that were prevalent when the disease was first discovered. Recently the problem has become more critical, as Braun (1) has reported that at least three biotypes have been discovered in Europe and that a number of European varieties that were considered for years to be immune to wart have been found to be susceptible to the new races of the organism. So far there has been no evidence of the occurrence of new biotypes in the United States, but there is no assurance that new forms, which are more virulent and have a wider range of adaptation, will not be found.

Shortly after potato wart was reported in Pennsylvania work was begun cooperatively between the United States Department of Agricul-

ture and the Pennsylvania Department of Agriculture to test the susceptibility of the commercial varieties (6). Several of these, such as Green Mountain and Irish Cobbler, were found to be immune; others, such as the Rurals, proved to be very susceptible. A number of first-generation progenies were also tested, and many of the seedlings showed an immune reaction.

When it was found that some of the most important American varieties were immune, the problem was no longer considered of major importance. A limited program was continued, however, to test the varieties and seedlings that are used as parents in other phases of potato-breeding work and the seedlings that are promising from the commercial standpoint, especially those that are to be named and distributed to growers. The following portions of this paper give an account of the results of these tests from 1933 until the present time.

Materials and Methods

The tests were made at the higher elevations of Pennsylvania. The Russet Rural was used in all cases as a susceptible check. Five to fifteen hills of each seedling and an equal number of the check variety were planted in alternation in each plot. From 1933 to 1936, inclusive, the wart reaction test of the seedlings was made in peat moss in trenches with boarded sides. These trenches were dug to a depth of 5 inches, the seed piece was placed 1½ inches below the surface of the soil, and as soon as the shoot showed above ground it was covered with 3 inches of peat moss. Prior to planting, the seed piece was dipped into mud composed of 1 bushel each of soil and wart inoculum. The seedlings were uniformly watered from the 1st of August to the 15th of September. Normal development of the lots usually occurred.

From 1937 to 1940 a new method reported by Lemmerzahl (4) for testing wart reaction was used. The seed was sprouted and inoculated with fresh wart inoculum prior to planting. The eye of the sprouted potato was surrounded by a ring of petroleum jelly and filled with distilled water, and a fragment of live wart tissue was inserted. The seed piece was then placed in moist sand and stored at a temperature of 56° to 58° F. for 5 to 7 days before planting.

During the period 1941 to 1943 soils heavily infested with wart were planted to seedlings and checks,—10 hills of each. This method is less costly and just as effective as the two previous methods. Observations on wart infection were made each year at harvest time.

Results

The 15 varieties presented in table 1 were tested for wart as they became available over a period of years. They are all new American varieties except President which is a Dutch variety. The five varieties Katahdin, Mohawk, Sequoia, Mesaba, and Norkota are considered immune to wart. Houma is very resistant. Chippewa, Sebago, Golden, Erie, Earlaine, President, Earlaine 2, Potomac, and Warba are classified as susceptible to this disease. All the immune and very resistant varieties, except Mesaba, have Katahdin as their male parent.

Table 1. *Wart reaction of potato varieties recently introduced.*

Variety	Parentage	Number Years Tested	Wart Reaction
Katahdin	40688 x 24642	5	Immune
Chippewa	do	2	Susceptible
Sebago	Chippewa x Katahdin	3	Susceptible
Mohawk	Green Mountain x Katahdin	6	Immune
Sequoia	do	2	Immune
Houma	Charles Downing x Katahdin	7	Very resistant
Golden	43106 x 43543	1	Susceptible
Erie	45146 x Earlaine	4	Susceptible
Earlaine	Irish Cobbler x 43055	2	Susceptible
President	....	1	Susceptible
Earlaine 2	....	1	Susceptible
Mesaba	Russet Rural x Minnesota 41-1	1	Immune
Potomac	Rural New Yorker x Katahdin	1	Susceptible
Norkota	do	1	Immune
Warba	Triumph x Minnesota 4-16	1	Susceptible

Fourteen crosses and two selfed lines, totaling 117 seedlings, with the number of seedlings in each family and their reaction to wart, are given in table 2. The total number of seedlings in each family is too small for a genetic analysis. However, 10 progenies segregated for at least one or more immune seedlings. Seven of these ten progenies had Katahdin as a parent. By grouping the two progenies, Katahdin selfed and Katahdin naturally pollinated, the total number of seedlings tested was 32. Fourteen of these were found immune; 2, very resistant; and 16, susceptible. Since the natural pollination was doubtless with Katahdin pollen it may be concluded that the selfing of an immune variety resulted in about 50 per cent of its progeny showing high resistance to potato wart.

TABLE 2. *Seedlings grouped by parentage and their reaction for wart resistance.*

Parentage	Seedlings Tested	Seedling Reaction to Wart		
		Immune	Resistant	Susceptible
	Number	Number	Number	Number
Chippewa x Katahdin	8	3	0	5
Charles Downing x Katahdin	3	0	0	3
43322 x Katahdin	2	1	0	1
43752 x Katahdin	5	2	0	3
44367 x Katahdin	3	2	0	1
Earlaine x 43055	10	0	0	10
Irish Cobbler x Earlaine	3	0	0	3
47005 x 46923	12	5	0	7
336-123 x 46422	6	0	0	6
Katahdin (naturally pollinated)	9	2	0	7
Katahdin selfed	23	12	2	9
3895-13 x Earlaine	5	2	1	2
47007 x 46923	10	0	0	10
Chippewa x 46923	10	0	3	7
47562 x 47156	4	3	0	1
Katahdin x 96-56	4	1	0	3
Total	117	33	6	78

In addition to those shown in tables 1 and 2, a total of 60 seedling varieties of value as parents and commercial possibilities was tested, and 11 were found immune; 4, very resistant; and 45, susceptible to potato wart.

SUMMARY

Potato wart is still confined to restricted areas in Pennsylvania, from which state it was first reported. Its spread has been controlled by temperature and moisture relationships, by immune varieties, and by strict regulations that have been applied to the importation of foreign potatoes, as well as those governing the growing of potatoes in the infested area. Recently the problem has become more critical, as at least three biotypes of the organism have been isolated in Europe, and a number of varieties there that have been considered immune from wart are susceptible to the new races. So far there has been no evidence of the occurrence of new biotypes in the United States, but there is no assurance that new forms having greater virulence and a wider range of adaptation will not be found.

The wart reaction of 14 new American varieties and the Dutch variety President indicates that Katahdin, Mohawk, Sequoia, Mesaba, and Norkota are to be considered immune, and that Houma is very resistant.

A total of 117 seedlings from 14 crosses and 2 selfed lines was tested. Segregation for resistance occurred in 10 of these lines. Seven of these ten progenies had Katahdin as a parent. Two selfed lines of Katahdin showed, after grouping, about 50 per cent of their seedlings to be very resistant to wart.

Sixty other seedling varieties of value as parents and commercial sorts were also tested, and 11 were found immune; 4, very resistant, and 45, susceptible.

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SECTIONAL NOTES

INDIANA

The potato situation has slightly changed for the better,—for we have had some fall rains and the possibilities for improved yields are bright. The shortage of labor and materials, particularly sacks, may delay some of the marketing but very few seem to get excited or worried which leads me to believe that a lot of the potatoes will be sold right at the field.

The Katahdins, Chippewas, and a few odds and ends, such as Sequoia, and Sebago, are excellent in quality, of good size, and as a rule, are producing one-half a yield. (Oct. 2).—W. B. Ward.

KENTUCKY

The breaking of our summer drought (perhaps, better,—customary drug summer season)—came earlier in August than usual, to make the potatoes' situation quite as good as that of our banner year, 1929. Enough rain fell to "make the crop", where the fields had been kept in good tilth. Sebago and Sequoia, particularly, show splendid promise, and so does Chippewa. These three varieties have consistently outyielded Irish Cobbler, where moisture was plentiful and frost has held off, as it appears to be doing now.

The trick in all this is that we now have the smallest "second crop" ever planted. Our men became discouraged by the drubbing they took with the early crop. (Oct. 3).—JOHN S. GARDNER.

MICHIGAN

Michigan growers are still digging—the season has been late. Because of the extremely dry climatic conditions during July and August, with rains coming during September, our growers postponed harvesting operations to take advantage of the late growth.

The quality is generally very good. Our yields in the late sections are also good and the growers are selling quite freely. The car movement to date is slightly above last year.

Certified seed yields and quality are about normal. There is a slight increase in acreage compared with that of 1943. (Oct. 10).—H. A. REILLEY.

NEBRASKA

The harvesting of the Nebraska main crop swung into high gear during the first week in October. This is about normal for the western Nebraska territory, where the main crop is produced. Until that time, most of the area had received no killing frost, and except for an occasional field, considerable difficulty was being experienced with the immaturity of the potatoes. This resulted in some cracking and considerable feathering.

A strenuous campaign was initiated by the Nebraska Potato Improvement Assocation to do what is known as "under-cutting" the vines. This consists of passing a blade beneath the potatoes, as they lay in the row, to sever all the roots. By this process, the intake of water is reduced, and brittleness, that causes cracking, is materially lessened. This procedure has improved digging conditions materially.

At this writing (October 11), the crop is probably two-thirds

under cover. With another week of favorable weather, the major portion of the crop will be safely stored away. The yields and quality on both dry land and irrigated, are fair to very good. These variations are due to the unusual growing conditions of the past season. As reported during the course of the summer, our territory was visited by torrential rains, and severe hail storms. Practically no rain fell without being accompanied by hail in some place in the territory. Many of these storms were the most severe on record. It is not unusual for the same area to be visited by three or four severe storms of this nature. In those cases, there were practically no crops produced. Potatoes suffered, along with wheat, corn, sugar beets, etc. Even though the fall has been quite late, potatoes in those areas which should yield 300 or 400 bushels are running 75 to 100.

There is some demand for certified seed potatoes, and original quotations for future delivery are being sold at ceiling prices. For some years past, Nebraska growers have contracted very few of the potatoes at the time of harvest. Two reasons exist for this reluctance to contract: first, the hazard of getting the potatoes under cover before severe freezing; and secondly, the desire to have a final bin inspection, to determine whether the stock will meet certification requirements before making the sale.

There has been considerable sale of table stock and commercial seed from the field. Much of this stock is going into the dealers' storage houses. The grower is being paid from $1.00 to $1.35 per cwt. from the field,—depending upon quality. This, of course, is net, without sacks and grading. The prices being obtained for table stock range from 10 cents or 15 cents below, to ceiling prices.

There is no indication of what the plans may be for another season, but this will materialize as we go farther into the marketing season of this crop. (Oct. 14).—Marx Koehnke.

NEW YORK

The weather has been generally favorable for potato harvesting in most sections to date (October 12). In Rennselaer and Washington Counties in Eastern New York, the yields have been high and the quality good. This is the only area where rainfall was sufficient to result in some blight rot, some oversize and a better than average yield. Steuben County has a lower yield than that predicted on August 1, but still they have a good crop of excellent quality. Also the muck crop has been better than expected, following the hot dry season. Elsewhere in

upstate New York, the yield has been rather disappointing. Many growers are waiting for the crop to develop larger tubers as a result of the late rains and a resumption of foliage growth. This always means danger of freezing that portion of the crop in the field.

The potato market has been dull during early October and there is a tendency to store in view of the short crop. Our harvesting operations are about completed on Long Island. No. 1 Green Mountains at Long Island shipping points are selling at $2.40 to $2.60 cwt. with light haulings. The upstate shipping point price to growers for Katahdins and Chippewas in Rochester area is $2.30 cwt.

The Empire State Potato Club has announced dates for its annual convention and state potato show at Hotel Ten Eyck, Albany, New York, on the 4th and 5th of January, 1945. As usual, it will be a joint convention with the New York State Vegetable Growers' Association. (Oct. 13).—E. V. Hardenburg.

OHIO

The late potato crop in Ohio suffered from drought and hot weather extending the growing period so that the vines were still green until heavy frost on the 15th of October. Many growers harvested their late potatoes while the vines were still green.

Most of the Russet fields have made second growth and the tubers are ill-shaped. The total Ohio crop is about 60 per cent of the 10-year average yield of 1933-1942.

Potatoes were selling at ceiling prices on the last day of September, the ceiling being 3.00 f.o.b. farm. On the 1st of October the ceiling dropped to $2.45. Naturally, this caused considerable confusion in the markets and many potatoes were sold on the black market. The ceiling price of shipped-in potatoes is considerably above the ceiling price of Ohio potatoes and this naturally contributes to black market practices.

It is too early to predict the acreage trends of next year with the exception of small acreages, both garden and farm, which will be further reduced in 1945. (Oct. 16).—Earl B. Tussing.

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THE EFFECT OF SULPHUR AND ACID FERTILIZER ON INCIDENCE OF POTATO SCAB*

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The relation of soil reaction to incidence of potato scab (*Actinomyces scabies* (Thaxt) Güssow) has been studied by many investigators. The literature on this subject has been well reviewed by Dippenaar (4) and further brought up to date by Ken Knight (7).

Although in certain areas, decrease of potato scab in alkaline soil has been noted by Goss, (6), Smith, (9), Blodgett and Howe, (1), Blodgett and Cowan, (2), and Larson, Albert and Walker, (8), the general concensus of opinion seems to be that lowering the soil reaction particularly below pH 5.2 also decreases the amount of the disease on the crop when grown in scab-infested soils. This is usually accomplishes by the addition of sulphur to the soil or as shown by Cook and Nugent (3) by the use of acid-forming fertilizer.

In many areas of Michigan, it is the custom to grow potatoes on fields where alfalfa has been plowed under to increase humus content of the soil. It is often necessary to make applications of ground limestone, marl or hydrated lime to these soils to bring the soil reaction up to a

[1]The writers are indebted to Mr. A. M. Berridge, Supt. Lake City Experiment Station, Lake City, Michigan, for providing facilities for carrying on this project and his continued interest in the investigation. This investigation represents part of the work done under the cooperative Michigan Experiment Station-Bankhead-Jones Project 1B.

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level suitable for growing the alfalfa crop. On soils so treated although good conditions obtain for growing potatoes, the incidence of potato scab often increases to such extent that serious losses to the crop result. Field experiments were therefore undertaken to find out (1) if by addition of sulphur and acid fertilizer the soil reaction could be lowered to such extent that growth of the scab organism would be inhibited without serious reduction in yield of potatoes and (2) whether after treatments with sulphur and acid-forming fertilizer the later addition of lime to the acid reacting soil would result in renewed activity of the scab parasite.

Plot Location and Treatments

The plots were laid out on a 2¾ acre field at the Lake City Experiment Station, Lake City, Michigan. The soil was Ottawa sandy loam and typical of that of many fields where potatoes are grown commercially in the northern part of the state. The soil had been uniformly infested with the scab organism in manure cultures and by scattering over it scabby potatoes after harvest in 1937 and 1938. The same plots were used each of the four years 1939-1942 inclusive and were given a heavy coating of manure in the winter between crops of potatoes.

The experiment was set up in series of 12 plots, 50 feet x 24 feet, randomized for treatment and replicated three times, with a 15-foot aisle between each series. Soil tests over the entire tract showed the soil reaction to vary between pH 4.5 and 6.0.

The soil treatments were as follows

1. 400 pounds of sulphur disked into the top 6 inches of soil; 500 pounds of acid 4-16-8 fertilizer applied in bands at planting.
2. 800 pounds of sulphur and 500 pounds of acid 4-16-8 fertilizer applied as in (1).
3. 400 pounds of sulphur plowed under to a depth of approximately 8 inches; 500 pounds of acid 4-16-8 fertilizer in bands at planting.
4. 800 pounds of sulphur and 500 pounds of acid 4-16-8 fertilizer applied as in 3.
5. 400 pounds of sulphur plowed under as in 3 and 400 pounds disked in as in (1); 500 pounds of acid 4-16-8 fertilizer applied in bands at planting.
6. 800 pounds of sulphur plowed under and 800 pounds disked in and 500 pounds of acid 4-16-8 fertilizer applied in bands at planting (5).
7. 200 pounds of sulphur were mixed with 500 pounds of acid 4-16-8 fertilizer and the entire 700 pounds applied per acre in bands at planting.
8. 400 pounds of sulphur mixed with 500 pounds of acid 4-16-8 fertilizer and the entire 900 pounds applied per acre in bands at planting.
9. 500 pounds of acid 4-16-8 fertilizer per acre applied in bands at each side of and level with the seed piece.
10. 500 pounds of commercial 4-16-8 fertilizer applied as in (9).
11. Seed pieces rolled in sulphur and 500 pounds per acre of acid 4-16-8 fertilizer applied in bands at planting.
12. 200 pounds of sulphur mixed with 500 pounds of acid 4-16-8 fertilizer and the entire 700 pounds applied per acre in bands at planting; seed pieces rolled in sulphur.

Materials and Methods

The sulphur used was commercial sulphur flour. The acid fertilizer was made by mixing appropriate amounts of ammonium sulphate, special acid reacting superphosphate and potassium sulphate without lime filler. The sulphur was applied to the soil surface with a grain drill and either disked into the soil or plowed under as required. First sulphur applications were made in April, 1939. A second duplicate series of applications was made in October 1939, after harvest. Soil acidity readings were made in September, 1939, 1941 and 1942, and in July and in August, 1940. Soil samples were taken from the potato hill with no attempt to determine whether the tubers in the hill were scabby.

Untreated potatoes were planted on the plots in early May each year using a two-row mechanical planter. The Chippewa variety was used in these tests because of its susceptibility to scab. They were harvested in late September each year. Records were made of the tubers harvested from 40 feet of the two center rows of the 8-row plots. Tubers were graded into four classes, namely—clean, light, moderate and heavy scab and the weight of each lot tabulated. The degree of scabbiness was arbitrarily determined as follows: light scab, 1 to 5 scab lesions; moderate scab, 6 to 10 lesions; heavy scab, more than 10 lesions; and clean, no evidence of scab. Each grade of scabby tubers was weighed and its percentage of total yield taken as the scab index. In each of the four years, the light scab for the most part could have been included with the clean tubers as marketable potatoes. Only a few of the potatoes graded as moderate scab and none of those graded as heavy scab could have been included as marketable. Since the grower is primarily interested in the salable part of his crop, the degree of scab control is expressed as percentage of clean tubers and salable tubers, including both clean and light scab.

Results of 1939

The average percentages of clean and salable tubers (clean and light scab) from the three replicated plots of each treatment in 1939 are given in table 1.

Just before harvesting, soil samples were taken from each plot and pH readings made. These data are presented in the table as an average for the three plots of each treatment. From the data in table 1, it is seen that with the exception of plots with treatment 9, the soil reaction was more acid than is usually considered as suitable for scab development. Also, it was considered too acid for optimum growth of the potato plant.

TABLE 1—*Soil treatment and reaction (pH) of plots in* 1939 *and percentage and yield per acre of clean and salable tubers, and total yield per acre. Average of three plots. Lake City Experiment Station, Lake City, Michigan.*

Treatment	Soil	Clean Tubers		Salable Tubers		Total Yield
	pH	Per cent	Yield Bu. per Acre	Per cent	Yield Bu. per Acre	Bu. per Acre
1)* 400 lbs. sulphur disked in	4.5	42.4	53.4	61.9	78.0	126.1
2)* 800 lbs. sulphur disked in	4.0	32.1	41.2	51.4	66.0	128.4
3)* 400 lbs. sulphur plowed down	4.0	52.8	53.8	78.6	72.8	102.0
4)* 800 lbs. sulphur plowed down	4.2	42.5	45.2	63.2	67.2	106.3
5)* 400 lbs. sulphur plowed down 400 lbs. sulphur disked in	4.6	45.4	62.5	73.1	100.5	137.5
6)* 800 lbs. sulphur plowed down 800 lbs. sulphur disked in	4.0	66.6	65.8	80.3	79.3	98.8
7) 200 lbs. sulphur mixed with 500 lbs. acid 4-16-8 in bands	4.2	49.8	51.3	68.7	70.7	102.9
8) 400 lbs. sulphur mixed with 500 lbs. acid 4-16-8 in bands	4.0	34.0	32.4	64.9	61.7	95.1
9) 500 lbs. acid 4-16-8 in bands	5.0	33.7	40.1	50.8	60.4	119.0
10) 500 lbs. commercial 4-16-8 in bands (Check)	4.5	11.7	11.4	34.9	33.9	97.3
11) Seed piece rolled in sulphur 500 lbs. acid 4-16-8 in bands	4.3	46.2	46.5	66.0	66.2	100.4
12) Seed piece rolled in sulphur 200 lbs. sulphur mixed with 500 lbs. acid 4-16-8 in bands	4.2	47.7	50.9	68.1	72.7	106.7

*500 pounds per acre acid 4-16-8 applied in bands at planting.

However, potato scab was found in abundance in all treated plots. It is also seen that there was a general increase in percentage and yield of both clean and salable tubers from all treated plots.

Greatest increases in clean and also salable tubers were obtained from plots receiving 800 pounds of sulphur which was turned under to a depth of 6-8 inches followed by an application of 800 pounds, disked into the top 4 inches of soil. Increases in yield of clean tubers on all treated plots, ranged from 21 bushels to 54 bushels compared with the check (treatment 10) in which no sulphur was used and 500 pounds per acre of commercial 4-16-8 fertilizer were applied. There also was an increase in clean and salable potatoes from plots treated with acid reacting fertilizer (treatment 9.) There was no indication that the total yield of potatoes was reduced by additions of sulphur during the first year of the experiment but later, however, sulphur definitely depressed the yield.

Results in 1940-1941 and 1942

In evaluating the results of soil treatments for the years 1940 to 1942 inclusive, it must be noted that the applications of sulphur in May 1939, were duplicated in October of that year. Thus each treated plot received twice as much sulphur for the season of 1940. No further sulphur applications were made during 1940-1942. The additional sulphur applications were made to find out if the soil acidity could be increased to such an extent that growth of the scab organism would be further inhibited and what effect increased amounts of sulphur would have on growth of the potato plant. The result of the 1940 trials are presented in table 2.

After additional applications of sulphur in treatments 1 to 6 inclusive, the soil pH was higher in 1940 than in 1939. This may have been due to the fact that free sulphur, included in the first year's sample's, affected the reading. The 1939 tests were made with a "Soiltex" outfit and those in 1940 were made using colorimetric indicators.

As in 1939, the percentage of clean tubers was increased over the check by all treatments with greatest increase from treatment 6 which had in two applications received 3200 pounds of sulphur, one-half of which was plowed under and one-half disked into the top 4-6 inches of soil. The smallest percentage increase was obtained from treatment 9 in which no sulphur was added to the soil but acid reacting fertilizer was applied in bands at time of planting. Increases in percentage of clean tubers compared with those of 1939 were obtained from treatments 2 to 7 inclusive but decreases from treatments 1, 8, 9, 11 and 12. Increases in percentage and yield of salable (clean and light scab) tubers

TABLE 2—*Soil treatment and reaction (pH) of plots in 1940 and percentage and yield per acre of clean and salable tubers and total yield per acre. Average of three plots. Lake City Experiment Station, Lake City, Michigan.*

Treatment	Soil	Clean Tubers		Salable Tubers		Total Yield
	pH	Per cent	Yield Bu. per Acre	Per cent	Yield Bu. per Acre	Bu. per Acre
1)* 800 lbs. sulphur disked in	5.30	39.0	18.6	58.1	28.3	48.3
2)* 1600 lbs. sulphur disked in	5.03	45.0	18.5	59.4	24.5	42.8
3)* 800 lbs. sulphur plowed down	4.40	58.2	20.9	77.2	27.5	35.2
4)* 1600 lbs. sulphur plowed down	4.86	65.1	20.6	78.6	23.9	30.3
5)* 800 lbs. sulphur plowed down 800 lbs. sulphur disked in	4.90	59.2	28.9	75.8	39.4	52.3
6)* 1600 lbs. sulphur plowed down 1600 lbs. sulphur disked in	4.20	95.7	12.7	100.0	13.7	17.3
7) 200 lbs. sulphur mixed with 500 lbs. acid 4-16-8 in bands	5.00	65.8	21.0	72.0	24.1	36.9
8) 400 lbs. sulphur mixed with 500 lbs. acid 4-16-8 in bands	4.86	22.7	11.5	41.4	21.9	55.0
9) 500 lbs. acid 4-16-8 in bands	5.40	17.1	9.2	24.7	13.1	62.0
10) 500 lbs. commercial 4-16-8 in bands (Check)	5.43	3.7	2.1	13.6	8.9	60.6
11) Seed piece rolled in sulphur 500 lbs. acid 4-16-8 in bands	5.33	27.0	15.2	43.8	25.7	61.3
12) Seed piece rolled in sulphur 200 lbs. sulphur mixed with 500 lbs. acid 4-16-8 in bands	4.56	38.4	17.7	58.1	27.6	50.6

*500 pounds per acre acid 4-16-8 applied in bands at planting.

followed generally those of clean tubers. The highest percentage of clean tubers and the lowest total yields were obtained from treatment 6 receiving the maximum sulphur application. The stand of plants was greatly reduced in 1940 on these plots, the number of plants on the three replicates being 40, 144 and 76 respectively. There also was evidence of sulphur injury on some of the tubers from this treatment.

Although an application of acid 4-16-8 fertilizer alone or mixed with 200 or 400 pounds of sulphur reduced scab, the increases in clean tubers from these treatments were not so great as from the use of heavy application of sulphur worked into the soil before planting.

Rolling the seed pieces in sulphur resulted in increased percentage of clean tubers as compared with applications of acid fertilizer alone.

The results in 1941 were comparable to those of the previous year and are shown in table 3. The percentage of clean tubers was greatest on the treated plots. Treatment 6, again showed the least total yield and highest percentage of clean and salable tubers. The percentage of salable tubers was least from treatment 9 in which only acid reacting fertilizer was applied. The soil reactions showed a change to the more acid for each plot as compared with readings of 1940, the greatest lowering of pH being from treatments 5 and 6 receiving 1600 and 3200 pounds of sulphur respectively in two applications in 1939. It is interesting to note the difference of soil reaction in treatments 2, 3 and 5 showing approximately the same percentage of clean tubers, 48.6 per cent, 52.6 per cent and 53.7 per cent respectively with pH readings of 4.46, 4.28 and 3.44. If soil acidity were the determining factor in scab infection, it would seem that there should be greater variation in percentage of clean tubers between these treatments.

The total yields of tubers were much greater in 1941 than in either previous year because of the favorable growing conditions. There was a reduction in yield probably due to previous heavy applications of sulphur on plots receiving treatment 6. There was also a slight reduction in stand in these replicates.

In October, 1941, applications of hydrated lime were made at the rate of 1500 pounds per acre to the plots of treatment 6, which had previously received additions of 3200 pounds of sulphur per acre. This was done to find out if the scab organism had been killed by the previous sulphur treatment or only inhibited in growth during the previous year. If it had been only inhibited, then increasing the soil pH should furnish better conditions for its growth and scab infection should also increase. Soil reaction in 1942 remained approximately as for 1941 on all plots except those receiving 1500 pounds of hydrated lime on which

TABLE 3—*Soil treatment and reaction (pH) of plots in 1941 and percentage and yield per acre of clean and salable tubers and total yield per acre. Average of three plots. Lake City Experiment Station, Lake City, Michigan.*

Treatment	Soil	Clean Tubers		Salable Tubers		Total Yield
	pH	Per cent	Yield Bu. per Acre	Per cent	Yield Bu. per Acre	Bu. per Acre
1)* 800 lbs. sulphur disked in	4.60	17.8	30.9	45.3	78.7	173.6
2)* 1600 lbs. sulphur disked in	4.46	48.6	85.8	75.9	134.2	176.7
3)* 800 lbs. sulphur plowed down	4.28	52.6	98.9	78.9	148.3	187.9
4)* 1600 lbs. sulphur plowed down	4.38	61.1	110.7	87.1	157.7	181.1
5)* 800 lbs. sulphur plowed down 800 lbs. sulphur disked in	3.44	53.7	94.4	86.3	151.8	175.9
6)* 1600 lbs. sulphur plowed down 1600 lbs. sulphur disked in	3.79	83.4	93.2	93.4	104.4	111.8
7) 200 lbs. sulphur mixed with 500 lbs. acid 4-16-8 in bands	4.23	35.8	58.7	67.7	110.9	163.8
8) 400 lbs. sulphur mixed with 500 lbs. acid 4-16-8 in bands	4.04	20.7	25.1	47.4	57.4	121.2
9) 500 lbs. acid 4-16-8 in bands	4.95	8.1	12.1	15.6	23.3	149.6
10) 500 lbs. commercial 4-16-8 in bands (Check)	5.41	2.7	4.8	25.3	45.1	178.6
11) Seed piece rolled in sulphur 500 lbs. acid 4-16-8 in bands	4.75	17.2	26.3	51.8	79.1	152.6
12) Seed piece rolled in sulphur 200 lbs. sulphur mixed with 500 lbs. acid 4-16-8 in bands	4.38	31.1	48.1	50.8	92.6	154.9

*500 pounds per acre acid 4-16-8 applied in bands at planting.

the reaction was changed from pH 3.79 to 5.38. Results for 1942, (table 4) show that for all treatments except numbers 10, the check and 12, there was a further decrease in percentage of clean and of salable tubers. In contrast with results of 1940 and 1941, the percentage of clean tubers from treatment 6 dropped from 95.2 and 86.9 respectively to 34.1. These results show that the scab organism during previous years of the experiment had not been killed by the treatment and needed only more nearly optimum soil reaction to cause increased infection. Thus in these experiments, applications of sulphur afforded only temporary relief from scab infection while the soil reaction was too low for the best growth of the potato plant. When this level was raised to more nearly optimum for the growth of the crop, then scab increased rapidly on the current crop. Similar results were obtained by Eddins (5) in Florida where limestone was applied after sulphur between potato crops for two years.

It is also indicated that soil acidity is not alone the controlling factor in scab infection, as is shown by percentages of clean tubers in all plots with soil reaction less than pH 5.0. In every case with the exception of treatments 10 and 12 in 1942, the percentage of clean tubers was less than that on the same plots in 1941. It appears that free sulphur in the soil also may have been at least partly responsible for decrease in scab infection. It is also shown that the scab organism may adjust itself to more acid soil conditions and produce infection under these conditions.

Discussion

Several interesting facts are shown by the data in considering the results over the four-year period. The special acid fertilizer without sulphur applied in bands slightly increased the acidity of the soil in the region of the hill and increased the percentage of clean tubers, although it apparently had no different effect on the total yield or yield of salable potatoes in comparison with fertilizer of the usual non-acid type.

Applications of sulphur were effective in reducing the soil reaction and in increasing the percentage of clean tubers and yield of salable potatoes, without greatly influencing the total yield per acre, except when applied in a manner that caused direct injury to the plant through contact with free sulphur. This is shown by the plots receiving band applications of 400 pounds of sulphur and 500 pounds of acid fertilizer per acre (treatment 8, 1939).

In 1940 percentage yield of clean tubers was increased when the amount of sulphur applied was sufficient to decrease the soil reaction

TABLE 4—*Soil treatment and reaction (pH) of plots in 1942 and percentage and yield per acre of clean and salable tubers and total yield per acre. Average of three plots. Lake City Experiment Station, Lake City, Michigan.*

Treatment	Soil	Clean Tubers		Salable Tubers		Total Yield
	pH	Per cent	Yield Bu. per Acre	Per cent	Yield Bu. per Acre	Bu. per Acre
1)* 800 lbs. sulphur disked in	4.60	14.6	12.6	37.7	32.6	86.5
2)* 1600 lbs. sulphur disked in	4.70	24.0	18.3	52.6	40.2	76.3
3)* 800 lbs. sulphur plowed down	4.80	42.9	36.0	67.0	53.9	80.4
4)* 1600 lbs. sulphur plowed down	4.60	34.9	30.3	67.8	58.0	86.8
5)* 800 lbs. sulphur plowed down 800 lbs. sulphur disked in	4.53	32.3	28.1	60.6	53.7	86.9
6)* 1600 lbs. sulphur plowed down 1600 lbs. sulphur disked in	5.38	34.1	28.1	58.5	48.2	82.4
7) 200 lbs. sulphur mixed with 500 lbs. acid 4-16-8 in bands	4.63	32.1	22.3	57.2	39.7	69.3
8) 400 lbs. sulphur mixed with 500 lbs. acid 4-16-8 in bands	4.97	17.9	12.5	43.5	30.4	69.8
9) 500 lbs. acid 4-16-8 in bands	5.13	3.2	2.7	12.7	10.8	84.7
10) 500 lbs. commercial 4-16-8 in bands (Check)	5.41	3.8	2.8	22.8	16.6	72.8
11) Seed piece rolled in sulphur 500 lbs. acid 4-16-8 in bands	5.13	12.5	8.4	30.1	20.2	67.2
12) Seed piece rolled in sulphur 200 lbs. sulphur mixed with 500 lbs. acid 4-16-8 in bands	4.30	31.8	20.2	58.6	37.2	63.5

*500 pounds per acre acid 4-16-8 applied in bands at planting.

enough to inhibit the growth of potatoes as in the case of the plots receviing respectively 1600 and 3200 pounds per acre (treatments 5 and 6). The soil reaction of these plots was too low for good growth, pH 3.4 and 3.8. 800 and 1600 pounds of sulphur per acre plowed under were more effective in reducing scab than the same amounts disked into the surface. Although 1600 pounds of sulphur per acre was more effective in scab control than 800 pounds when disked into the surface, there was no difference when they were plowed under. The maximum benefits on this soil were obtained with treatment 5 (800 pounds plowed under plus 800 pounds disked into surface). This plot as an average for the four years gave the highest total yield and the highest yield of salable potatoes. The plot receiving twice this amount of sulphur, treatment 6 (1600 pounds plowed under plus 1600 pounds disked into soil) yielded the largest percentage of clean potatoes, but since the total yield was much smaller the yield of salable potatoes was also much less.

The application of sulphur in this experiment did not completely control potato scab in any case. The highest percentage of clean potatoes was secured in 1940 on the plots that received 3200 pounds of sulphur per acre, where the soil reaction, pH 4.2, was too low for best growth of potatoes. Only 4.3 per cent of the potatoes on these plots were scabby. However, where sufficient lime was applied in 1942 to bring the soil reaction to approximately pH 5.4 scab increased to 65.9 per cent of the crop.

In all treated plots with the exception of number 2, there was a slight decrease in 1941 in the percentage of clean potatoes as compared with the 1940 crop harvested after the second application of sulphur. In general, the soil reaction for these plots in 1941 showed in most cases lower pH than in 1940. In 1942, the soil pH was slightly higher than those of 1940 in all, with the exception of two plots. The percentage of clean potatoes on all treated plots except the check was much lower in 1942 than in any of the previous years.

Summary

1. Applications of acid fertilizer alone and in combination with sulphur in bands or when used with sulphur plowed under or disked into the soil reduced potato scab infection.
2. Greatest reduction of scab resulted from applications of 3200 pounds of sulphur per acre and acid fertilizer but the yield of potatoes was seriously reduced.
3. The least amount of scab occurred in plots showing soil reactions of approximately pH 3.5-3.8.

4. It is shown that growth of the potato scab organism was only partially inhibited in soils of low pH and that it gradually adapted itself to these conditions.
5. When lime was added to raise the soil reaction to approximately 5.4, scab became more severe.
6. In comparison with the crop of 1939 there was a noticeable decrease in percentage of clean potatoes in the two crops following the second application of sulphur in 1940, although the soil pH in most plots remained lower, except where lime had been applied.

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THE MENOMINEE POTATO: A NEW VARIETY RESISTANT TO COMMON SCAB AND LATE BLIGHT

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A new variety of potato should not be distributed to growers unless it possesses at least one important character that gives it a decided advantage over the present commercial varieties for a particular environment. The Menominee[2] (528-118) has such a character. It is resistant to common scab (*Actinomyces scabies* (Thaxt.) Güssow). It is also moderately resistant to late blight (*Phytophthora infestans* (Mont.) DBy.), but this resistance is not considered so important as its resistance to scab. Common scab is widely prevalent throughout the potato-producing areas of the United States. The organisms are carried on seed potatoes and live over from year to year in the soil. A number of treatments have been recommended that kill the organisms carried on the seed tubers; but no methods of soil treatment or systems of rotation have yet been devised that will completely control scab infection resulting from soil-borne organisms.

In a number of areas scab is becoming a limiting factor in potato production to such a degree that the present commercial varieties, all of which are more or less susceptible to scab, will have to be abandoned in some localities and replaced by resistant varieties adapted to these areas. One of the projects under the national potato-breeding program has been the breeding of scab-resistant varieties. When the work was

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[2] Menominee is the name of an Algonquian tribe of Indians of the central group who have lived near the Menominee River, northwest of Lake Michigan, since its discovery by the white man early in the seventeenth century.

begun no varieties highly resistant to scab were available, but in the spring of 1934 a few tubers of the scab-resistant varieties Richter's Jubel, Hindenburg, and Arnica were received from A. P. Lunden, Aas, Norway. None of these varieties was well adapted to growing conditions in this country, so crosses were made between them and a number of American varieties and seedlings for the purpose of combining resistance to scab with other characters of commercial importance. A relatively large number of the progeny of these crosses were found to be highly resistant to scab. None of the seedlings was ideal in type, but a number of them were selected and sent to several cooperating state experiment stations for further scab tests and adaptation trials. Among the selections were several from the cross No. 528 Richter's Jubel x Seedling 44537. The pollen parent, Seedling 44537, had appeared as a russeted mutation in the cross Chippewa x Katahdin. It showed a fair degree of resistance to scab.

Menominee (528-118) was first grown in 1935 at Aroostook Farm, Presque Isle, Maine. In 1936 and 1937 it was tested for resistance to scab and in 1938 was sent to Michigan and a number of other states. It proved resistant to scab in all tests. In Michigan, considering all factors such as resistance to scab and late blight, yield, cooking quality, and growth habits, Menominee was superior to all other seedlings tested. Its late-maturing habit and its tendency to produce rather rough-shaped tubers will restrict its distribution, but it should for the present fill the need of many farmers who because of scab find it difficult, if not impossible, to grow U. S. No. 1 potatoes of the standard commercial varieties.

Description

Plants medium to large, upright, stems medium thick, prominently angled; nodes slightly swollen, slightly reddish-purple; internodes slightly reddish-purple; wings waved, green; stipules medium green, glabrous; leaves long narrow; midrib green, moderately pubescent; primary leaflets close, three pairs, lanceolate, mean length 39.99 ± 0.35 mm. (1.57 inches), mean width 22.96 ± 0.80 mm. (0.90 inch). index 57.37 ± 0.43; petioles green to slightly reddish-purple; secondary leaflets medium in number, on midrib between pairs of primary leaflets; tertiary leaflets many, small; inflorescence branching many-flowered; peduncles short to medium reddish-purple, highly pubescent; pedicels long, slightly pigmented, highly pubescent.

Flowers. Calyx lobe long, green to slightly pigmented, highly

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TABLE I. *Comparison of yield of Menominee and three other varieties of potatoes grown at Lake City, Rogers City, Mich.*

Variety	Yield per Acre								Mean of All Tests	
	Lake City				Rogers City		Chatham			
	1942		1943		1942		1942			
	U. S. No. 1	Total	U. S. No. 1	Total	U. S. No. 1	Total	U. S. No. 1	Total	U. S. No. 1	Total
	Bushels	Bushels	Bushels	Bushels	Bushels	Bushels	Bushels	Bushels	Bushels	Bushels
Menominee	428	449	258	276	342	354	266	290	324	342
Russet Rural	313	424	223	312	252	294	222	314	253	336
Chippewa	188	239	168	231	218	248	177	217	188	234
Sebago	348	399	205	241	322	339	203	217	270	299

TABLE 2. *Comparison of the scab resistance of Menominee and three other varieties of potatoes at Lake City, Michigan for 6 years,* 1938-1943, *and at Rogers City,* 1 *year,* 1941 (*The data are given as the percentage of tubers* 1⅞ *inches and over that were free from scab*).

Variety	Free from Scab							
	Lake City							Roger City
	1938	1939	1940	1941	1942	1943	Mean	1941
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
Menominee	70	90	83	98	97	91	88	100
Russet Rural	80	..	..	8	8	3	25	..
Chippewa	50	20	7	0	1	0	13	51
Sebago	70	60	80	1	2	23	39	75

pubescent; corolla large, medium lilac tips; anthers orange yellow; pollen medium to good; style straight; stigma ovate, green.

Tubers. Cubical, flattened at apex, width slightly greater than length, medium thick, mean length 74.60 ± 1.02 mm. (2.94 inches)[3], mean width 75.54 ± 0.62 mm. (2.97[3], mean thickness 58.48 ± 0.73 mm. (2.30 inches)[3]; indexes, width to length 102.11 ± 1.50, thickness to length 79.43 ± 1.86, thickness to width 77.75 ± 1.24; skin slightly flaky to moderate russet if allowed to mature; eyes medium deep; flesh white; sprouts rose purple; maturity late—about the same as Russet Rural and Sebago. Menominee should be planted early in the season so that it may have at least 120 days of growing weather.

Adaptation

The Menominee potato has been tested in a number of states. It has shown resistance to scab in all tests and a moderate degree of resistance to blight. The yields in the Michigan tests in comparison with Russet Rural, Chippewa, and Sebago are given in table 1.

The yield tests were in randomized replicated plots. The Menominee in all tests gave a higher yield of U. S. No. 1 potatoes than the other three varieties. The Russet Rural at Lake City in 1943 and at Chatham in 1942 produced a higher total yield than Menominee, but the latter produced a higher yield of U. S. No. 1 potatoes.

The scab resistance of Menominee in comparison with Russet Rural, Chippewa, and Sebago is shown in table 2. The data are given as the percentage of tubers 1⅞ inches and over that were free from scab. The Menominee gave a much higher percentage of clean tubers than the other varieties, with the exception of the Lake City test in 1938. Even in that test there was a decided difference between the scabby potatoes of the two varieties. The scab pustules on the Menominee were quite shallow, but those on the Russet Rural were deep. In all tests the scab pustules on the Russet Rural and Chippewa were very deep as contrasted with the more or less superficial scab on the Menominee and Sebago.

The Menominee has escaped late blight in both vines and tubers in tests in Michigan where the disease destroyed the tops and rotted the tubers of susceptible varieties. It should not be seriously injured by light to moderate epidemics of late blight.

Leaf roll and mosaic have not affected the vines of Menominee in the Michigan tests from 1938 to 1943. Many of the other seedlings

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[3]The mean of measurements of 50 tubers; average weight 7±0.7 ounces.

grown in close proximity had to be discarded because of infection with these diseases.

The cooking quality of Menominee is about equal to that of the standard variety Russet Rural. The tubers are firm, requiring a few more minutes to cook than those of the standard varieties.

The tubers are slightly rough and more irregular than those of Katahdin or Chippewa. Off-type tubers have a tendency to become indented at the seed end, in a manner similar to off-type Katahdin or Sequoia tubers. The plants of Menominee usually develop from four to seven tubers.

If the plants are harvested before they are mature the tubers are more easily separated from the vines than are those of Russet Rural or Sebago. In common storage Menominee has a relatively long rest period with the result that little sprouting occurs until late in the spring. In this respect it is equal or superior to Russet Rural and superior to Sebago.

Maine Tests

The scab resistance of Menominee was first shown in the tests on Aroostook Farm, Maine, but this variety has not been especially promising for that state in other characteristics. In 1943 it yielded about the same as Katahdin but was outyielded significantly by Green Mountain, Pontiac, Earlaine 2, Houma, Mohawk, and Sequoia.

It was comparatively low in dry-matter content with a mean density between 1.075 and 1.080. In this respect it was intermediate between Katahdin and Chippewa but was significantly lower than Green Mountain, Houma, Sebago, Mohawk, and Sequoia. Its cooking quality was good, but the cooked flesh was not so mealy as that of the varieties with the significantly higher specific gravities.

In 1943 approximately 2,800 bushels of seed stock of Menominee were produced in Michigan. Most of this seed will be grown for increase in 1944.

Summary

Menominee is a selection from a cross of Richter's Jubel and seedling 44537. Richter's Jubel is a scab-resistant European variety having little commercial promise in this country. Seedling 44537 was a russet mutation from the cross Chippewa x Katahdin; it was low-yielding but scab-resistant. Menominee is highly resistant to scab and moderately resistant to late blight.

Tests in Michigan show that if this variety, which is late ma-

turing, is planted early it will produce relatively high yields of potatoes of good cooking quality. Its tubers do not cling to the vines when harvested before the plants are mature as do the tubers of Russet Rural and Sebago.

Menominee has yielded consistently, more bushels of U. S. No. 1 tubers per acre at Lake City and Rogers City, Michigan, than Chippewa, Russet Rural, or Sebago.

It is scab-resistant in Maine where it was first produced and tested but has not been promising at Aroostook Farm, Maine, except for its scab resistance. It is intermediate there in yield and relatively low in dry-matter content.

Menominee is being distributed to growers in the late potato-growing sections where, because of common scab, U. S. No. 1 potatoes of the old commercial varieties can no longer be produced. It is hoped that a better scab-resistant variety will be available in the near future.

About 2,800 bushels of seed of Menominee were produced in 1943. Most of this will be grown for increase in 1944.

OUTLINE OF PROCEDURE FOR THE DIAGNOSIS OF BACTERIAL RING ROT OF POTATOES—REPORT OF THE COMMITTEE OF THE POTATO ASSOCIATION OF AMERICA

In response to a request made by motion at its 1941 meeting in Dallas, Texas, the Potato Association of America appointed a committee to standardize the procedure to be followed in the diagnosis of bacterial ring rot of potatoes. Questionnaires were sent to all persons known to be officially associated with the production or control of potatoes. Fifty-one replies were received; these formed the basis for the conclusions reached by the committee.

The committee finds that no single test is entirely reliable but that two or more tests should be used in combination whenever possible. Further, it finds that the test considered by the majority of plant pathologists to be most reliable is the Gram staining of smears made from the basal part of affected stems, and a close second, the Gram staining of smears made from diseased tubers, especially if the smears are made from visibly affected portions of the vascular ring, or from those that fluoresce under ultraviolet light.

There will always be a small percentage of cases where positive diagnosis is impossible. In such cases the next year's crop should be

kept under careful observation. The recommended procedure is outlined below.

A. Applicable to Routine Inspection in Field, Car, or Storage; or to the Elimination of Infected Tubers in a Lot of Seed Potatoes That One Desires to Save.

I. *Field Inspection.*

(a) *Vine Symptoms.* Vine symptoms consist of partial or complete wilting of one or more leaflets or leaves, accompanied by rolling, with loss of color to a dull light green, greyish green, with occasional mottling in some regions, and then yellow, followed by the death of the wilted parts (4,8). One or more stems in a hill may be affected, while the rest appears healthy. When the stem is cut across at the base and squeezed, a creamy exudate is expelled. This may be verified by staining smears with Reed's rapid Gram stain (8). (See appendix, also.)

When vine symptoms are present and no creamy exudate can be squeezed from the vascular bundles of the cut stems, the presence of the disease *must* be verified by the Gram staining of smears. Two smears should be made from each stem, about one inch apart, in order to be reasonably sure that at least one of the smears will be made in a region where the bacteria are abundant.

In cases where the disease is in an obscure form, presenting only slightly discolored points in the vascular system of the plant (2), the ooze test (1) may be applied. (See appendix, also.)

By the time vine symptoms appear, there will generally already be some of the tubers showing typical ring rot symptoms, and therefore the tubers should be dug and examined.

(b) *Tuber Symptoms.* Infected tubers cut at the stem end will show a cheesy rot in the region of the vascular ring, which is cream, yellow, or light brown in color (4,8). When potatoes are growing in wet soil, such as occur under irrigation or during wet seasons, the rot may extend straight down from the stem end into the pith (similar to black leg except for the color). In typical and sufficiently advanced cases, when pressure is applied, there will be a definite separation of the tissues outside of the vascular ring from the tissues on the inside. Severely soft-rotted tubers, namely those invaded by secondary organisms, will generally show external cracking of the skin (4, fig. 11). The presence of the disease may further be verified by the ooze test or by the Gram staining of smears.

Tubers suspected of being infected with bacterial ring rot, but

not showing definite symptoms as described above, *must* be verified by the Gram staining of smears. (See B, I, below).

II. Car or Storage Inspection.

(a) *Tubers.* (1) Apply procedure I, b, above.

(2) Ultraviolet light may be used as a presumptive test, but *must* be followed by I, b, above.

III. Elimination of Infected Tubers.

(a) Ultraviolet light may be used privately to eliminate any and all infected tubers (5, 6), but verification of the presence of ring rot *must* be based on the application of the rules under I, b, above.

B. Procedure to Be Followed in Other Than Routine Inspections; *e.g.*, When Routine Tests Under "A" Do Not Prove Satisfactory, or When Recourse to Law May Be Taken in the Case of the Sale of Supposedly Infected Seed Potatoes.

I. Gram-stained smears from stem or tuber must show Gram-positive bacteria, brilliantly stained, short rods, or elliptical to inequilateral in shape, 0.3.0.5 x 0.6-0.9 microns, occurring at least in small groups, usually as single cells, or in pairs, but occasionally in short chains. In tubers badly soft-rotted by secondary organisms and in old cultures, abnormal, large globular cells may be found. The occurrence of a few, single, scattered bacteria in a smear cannot be accepted as positive evidence of the presence of ring rot (8, 9, 10). Or:

II. Isolation and identification of the etiological agent (3, 7, 8, 9, 10.) Or:

III. Transmission of infection to a suitable host; presumptive in tomato and eggplant, positive in potato (9). The inoculated host plant must yield evidence as described in I or II, above.

Appendix

Reed's Rapid Gram Stain (8):

Solutions:	(1) Crystal violet (or gentian violet)	2.5	gms.
	Water	1000	cc.
	(2) Sodium bicarbonate	12.5	gms.
	Water	1000	cc.
	(3) Iodine	20	gms.
	Sodium hydroxide (molar solution)	100	cc.
	Water	900	cc.
	Dissolve the iodine in the sodium hydroxide solution, and dilute with the water.		
	(4) Ethyl alcohol, 95 per cent	750	cc.
	Acetone	250	cc.

(5) Basic fuchsin, saturated solution in 95 per cent
alcohol .... 100 cc.
Water .... 900 cc.

The solutions keep indefinitely. The procedure for staining is as follows: Flood the smear with equal parts of (1) and (2) for about 10 seconds, then drain off the excess. Flood with (3) for about 10 seconds, and then wash with water. Flood with (4) until no more color comes away, about 5 to 10 seconds, and then wash with water. Flood with (5) for not over 2 or 3 seconds, wash with water, and then dry. For immediate examination, the smears can be blotted lightly with filter paper, taking care that it does not slide over the surface. A drop of immersion oil can then be placed directly over the smear and examined under the oil immersion objective of the microscope.

Ooze Test (1):

The ooze test is made by preparing a thin slice of the suspected tissue, placing it in a drop of water on a slide, cutting it with a sharp knife and examining it under low or high dry objectives of a compound microscope. If bacteria are present there will be an extrusion of bacterial mass which is very readily discerned as a mass of fine specks like ground glass. This should not be examined in full light.

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D. P. GLICK, *Chairman*.
P. A. Ark.
H. N. Racicot.

SECTIONAL NOTES

INDIANA

Our potato harvests are over and the crop has been disposed or placed in storage. We will only have about one-half as many potatoes as will be consumed and some of the neighboring states are taking advantage of our situation and supplying our markets with good potatoes at a reasonable price.

The situation for 1945 will perhaps be the same as this year, not so much of a change in the larger commercial areas as our commercial growers have equipment on hand to handle increased acreage. The condition of the equipment, however, is like everything else—will have to be replaced sooner or later—and the availability of the equipment will somewhat determine the acreage to be planted and harvested for the next ten years. There will, however, be quite an increase in the smaller potato patches for home consumption for 1945 which should provide a good market for the growers of certified seed in the northern states. (Oct. 31).—W. B. Ward.

NEW JERSEY

The New Jersey potato crop of approximately 8,928,000 bushels has been harvested and practically all sold. It is believed that many less potatoes are held in storage this year than last. Several reasons contribute to this situation. In the first place, the late crop varieties especially Green Mountain did not produce a very good crop either in size or quality; secondly, the O.P.A. prices for winter and spring sales are not particularly enticing; thirdly, the experience of many growers with last season's storage deal was rather disappointing. The market at the present time is very slow, with Maine and Canadian potatoes being offered for $2.60 cwt. in carload lots at our local markets.

It is now anticipated that our growers will voluntarily reduce their acreage in 1945 from 5 to 10 per cent of the 72,000 acres planted in 1944. (Nov. 20).—J. C. Campbell.

NEW YORK

The harvesting of the 1944 potato crop was practically completed before the 1st of November. Weather conditions were favorable in most localities for our crop to go into storage in clean sound condition. There have been very few reports of tuber rot caused by late blight. The crop report on the 1st of November for New York indicates a yield of 26,863,000 bushels which is 2.5 per cent increase over the October

estimate, and 4.2 per cent below the 5-year average for 1939-1943. Western New York shipping point prices now range about $2.50 cwt., which is close to the November ceiling. The market is rather quiet and the growers who are holding stored potatoes generally feel that there are not too many potatoes to warrant early selling.

The preliminary listing of fields which met the requirements for certification shows the following acreages of seed by varieties:

Bliss Triumph	4	Sequoia	114
Warba	6	Cobbler	160
Earlaine 2	6	Sebago	559
Pontiac	13	Chippewa	701
Russet Rural	68	Green Mountain	999
Rural	77	Katahdin	1142
Houma	105		
		Total	3954

It is very possible that some of the crop from this acreage will not be certified, either because of failure to pass the Florida test or because of failure to grade properly.

Our plans are nearly completed for the 10th annual joint convention of the Empire State Potato Crop Club and the New York State Vegetable Growers' Association. The convention will be held at Hotel Ten Eyck, Albany, New York, on the 4th and 5th of January, 1945. A. G. Allen of Waterville is about ready for a big statewide competitive potato show consisting of 15 tuber samples of each of the 13 important varieties grown in this state. The Junior Vegetable Association and the 4-H Potato Clubs will also stage a competitive show and several judging and identification contests. The speaking program will consist mostly of joint sessions, with forums on such topics as labor-saving equipment and methods, use of surplus war machinery in our post-war agriculture, new methods of marketing after the war, and government production controls, subsidies, and price ceilings. (Nov. 14).—E. V. HARDENBURG.

OREGON

Our acreage of White Rose is up as compared with last year and Netted Gem and Burbank are off a little. These are the common varieties certified in our state. The acreage meeting the requirements of the field inspection as certified and Foundation seed is shown in the table below.

	1944	1943
Burbank	572	878
Netted Gem	1186	1249
White Rose	1341	692
Miscellaneous	40	76

In addition to maintaining a test plot within the state, plans have been completed to plant all of our common lots of certified seed, in the near future, at Oceanside, California near San Diego. In this way we hope to be able to get the readings of the test plots to the growers in time to be of value, both for marketing their crops and in selecting seed for the coming year. In our test plot work, we use 300 tubers from each lot, selected at random at the field and then plant the tubers whole. Planting of the whole tuber is to avoid any chance of spreading infection, and then, too, the whole tubers should give better stands and more vigorous plants.

We had a really beautiful harvest season this year in eastern Oregon with the vines killed rather early, followed by weeks of warm weather so that the crop moved into the cellars, perhaps in better shape than ever before. In western Oregon, there has been practically no blight and our July-planted fields are still green and growing. Some growers, satisfied with their crops, and apprehensive of winter rains, have killed the plants with spray and are now digging. This is mostly in the White Rose seed-growing area near Portland.

An innovation with Foundation seed is that we are, in addition to the San Diego plot, growing 300 tubers from each lot in a greenhouse so that growers of foundation seed can come to the greenhouse during the winter and check on their own seed. (Nov. 6).—E. R. JACKMAN.

PENNSYLVANIA

In 1943 Pennsylvania produced over 300,000 bushels of certified seed potatoes. This year it is expected that the production will be about 290,000 bushels. There is a nice crop of seed in the state this year,—including most of the common varieties except Russet. Many of our Russet fields failed to pass the certification requirements with the result that we have a short crop of certified seed of this variety.

Many fields were rejected because of wilt and ring-rot. During the hot dry period of August, Fusarium wilt developed in a number of fields of the Rural type. Ring-rot was also more widespread this year than usual because of the wide distribution given to the "War Approved" seed that was brought into Pennsylvania in 1943. A large

part of this seed showed evidences of ring-rot and many growers who did not have the disease before, contaminated their own seed stock through the "War Approved" seed that they planted.

A considerable amount of seed has already been moved, especially by those growers who did not have storage facilities to store their entire crop. (Nov. 14).—K. W. LAUER.

Most Pennsylvania potato growers discontinued spraying during the dry period of August and September. With the advent of cool damp weather during the latter part of September and early part of October, late blight developed on the new foliage. Since frosts came later than usual in the mountain sections the disease advanced sufficiently for tuber rots to be common in these areas. Losses up to 50 per cent have been reported by growers.

The common practice in Pennsylvania is to buy enough certified seed to increase so that the main crop is planted one year removed from certification. Many growers have recently expressed a doubt of the wisdom of buying any certified seed since perhaps 10 per cent of such seed that has been used in the state has been ring-rot contaminated. A general lack of confidence in certification as a disease control device seems inevitable unless this situation is corrected. Certification groups have a difficult but not insurmountable problem in ring-rot elimination. There is now enough available information that a unified and determined educational and regulatory campaign can be expected to succeed. (Nov. 13).—O. D. BURKE.

SOUTH DAKOTA

The potato crop in South Dakota was harvested in good shape and was all under cover before any serious freeze. In fact, even at this date the 8th of November, potatoes could still be dug in this area without being injured by freezing weather. Our yields have been fair and the quality of the certified stock is very good. There will be more certified seed for sale in South Dakota this year than last year because of the larger acreage entered for certifiction.

Sixty-nine hundred acres were entered for cartification in the state this year compared with forty-eight hundred last year. This season 5,652 acres passed all inspections. Only a small percentage of the certified stock has been sold or contracted for at the present time. Growers are confident that they will be able to sell at or near the ceiling price for the balance of the season.

The prices received for potatoes and the above average yields se-

cured for the past three years have made growers very optimistic and an increase in the certified acreage is expected next year. South Dakota growers were very fortunate this year in having many fields entirely free from Late Blight and only a trace of late blight was found in the remaining fields. The growing season was dry during July which prevented excessive vine growth and the dry warm weather prevented any infection from the Late Blight fungus.

The Bliss Triumph variety still comprises the largest proportion of the certified acreage in the state with 4,296 acres passing for certification. Other varieties certified include Irish Cobblers, Early Ohios, Pontiacs, White Rose, Red Warbas, Chippewas and Katahdins. (Nov. 8).—John Noonan.

CANADA

From several standpoints, the seed potato certification work during the season may be regarded as particularly satisfactory. The number of fields entered throughout Canada totalled only 8,500 as compared with 9,562 in 1943, and the number of fields which passed this year totalled 7,567 as compared with 5,520 last year. The average percentage of fields which passed was 89, as compared with only 57.7 in 1943. From the standpoint of acreage, there was entered this year 31,633, and in 1943 the acreage totalled 34,947. The percentage of acreage passed this year was 90.4 as compared with 54.8 last year.

Prince Edward Island led the provinces in percentage of acreage passed, with 95.6, Nova Scotia ranked second with 94.2, and New Brunswick third with 94 per cent of acreage entered. The situation in Ontario was also greatly improved, with 87 per cent of the acreage passed, and Alberta with 78 per cent.

The above results appear to support the policy established this year, whereby growers were required to plant seed of Foundation or Foundation A quality, whereas in previous years any seed grower could plant even marginal stock in the ordinary certified class. It must be borne in mind, however, that in 1943 the aphid population was the lowest for several years. Current season infection was, therefore, reduced accordingly. The following table shows a summary of inspection records for 1944, and comparisons in totals for the previous four years:

FIELD INSPECTION SUMMARY—1944

Province	Growers	Fields			Acres		
		Entered	Passed	Per cent	Entered	Passed	Per cent
P.E.I.	2,303	3,785	3,609	95.3	14,507	13,885	95.6
N.S.	129	286	268	93.7	630	594	94.2
N.B.	939	1,858	1,745	93.9	10,966	10,315	94.0
Que.	642	938	586	62.5	1,856	959	51.6
Ont.	413	729	644	88.3	1,753	1,527	87.1
Man.	61	123	82	66.6	267	207	77.5
Sask.	35	79	70	88.6	91	62	68.1
Alta.	102	176	146	82.9	320	251	78.4
B.C.	384	526	417	79.3	1,243	801	64.4
	5,008	8,500	7,567	89.0	31,633	28,601	90.4
1943	5,232	9,562	5,520	57.7	34,947	19,148	54.8
1942	5,201	7,947	5,023	62.2	29,981	18,875	62.9
1941	6,184	9,813	6,404	65.3	37,668	24,405	64.8
1940	7,700	12,388	8,676	70.0	48,111	34,094	70.1

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TOLERANCE TO PSYLLID YELLOWS OF POTATO VARIETIES AS REFLECTED IN YIELDS

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INTRODUCTION

In 1927, Richards and Blood (13)[4] discovered the relation of the tomato psyllid (*Paratrioza cockerelli* Sulc.) to the potato disease now known as psyllid yellows. Since that time several investigators (3, 4, 5, 8, 9, 10, 11, 12) have confirmed these findings as to the cause of the disease and have studied the biology of the insect, how it produces its effects on the plants, and the relation of various environmental factors to the incidence of the disease.

At the present time it is generally conceded that this disease is the most serious of those affecting potatoes in several of the Rocky Moun-

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[3]Plant Pathologist.
[4]Figures in parenthesis refer to literature cited.

tain and central Great Plains States. In some of these States, notably in the Plains region, the seriousness of the disease varies from year to year, apparently chiefly because of conditions which either favor or inhibit the multiplication of the insect.

Fairly effective methods have been developed and are extensively used in the control of this disease (2). However, these methods are based primarily on the use of power equipment and this adds considerably to the cost of production even on relatively large acreages. Home gardeners and growers of small acreages cannot afford to purchase power machinery and frequently it is not available for hire. Hand equipment can be used for very small plantings, but considerable skill and care are necessary to secure as effective control as is obtained with power machinery. For this reason investigations were initiated at the Cheyenne Horticultural Field Station in 1936 to determine whether or not an immune or tolerant potato variety could be found.

The results of the work in 1936 have been reported in a previous paper (1) in which it was shown that none of the 56 commercial varieties or 182 seedlings and South American varieties of potatoes under test was immune to psyllid yellows. However, there were great differences in yielding ability among them even though all showed typical and severe symptoms of the disease.

These results strongly indicated that true immunity from psyllid yellows is a rare or non-existent character in *Solanum tuberosum* L., but that varieties might be found that would make fairly satisfactory yields even though having the disease. The present paper presents the results obtained in a continuation of the study during 1937, 1938, and 1939.

Materials and Methods

In the 1937 test there were 54 commercial varieties and strains as well as 32 seedling varieties from the Colorado Potato Experiment Station, the Minnesota Agricultural Experiment Station, the Nebraska Agricultural Experiment Station, and the United States Department of Agriculture. Because of the large number of varieties involved they were divided into six groups, each of which was grown in a separate block. Within each block the varieties were grown in 5 replicate plots of 25 plants with Irish Cobbler, Rural New Yorker and Bliss Triumph as checks. The checks and test varieties were randomized within each block. For Cobbler and Rural New Yorker there were 5 check plots in each of the 6 blocks. However, in order to have the equivalent of 5 check varieties in each block the Bliss Triumph seed was divided into 3 lots designated as Bliss Triumph I, Bliss Triumph II, and Bliss Triumph

III. Each of these lots was treated as a separate variety. The field was irrigated and the usual commercial practices were followed in caring for the crop, except that the plants were not sprayed to control psyllids. Although most of the seed was secured from certified stock, some of the plants developed symptoms of mosaic or other diseases and were rogued out to eliminate, in so far as possible, all diseases except the one being studied.

All varieties were rated as to earliness of maturity. For this purpose the check varieties Irish Cobbler, Bliss Triumph, and Rural New Yorker were used as standards. Varieties as early maturing as Cobbler were given a rating of 1. Those in season with Bliss Triumph, which at Cheyenne is somewhat later than Cobbler, were given a rating of 2. Rural New Yorker represents about the latest varieties that can be grown at Cheyenne and varieties in season with it were given a rating of 3. Most of the varieties that were later than Rural New Yorker did not mature their tubers, their tops were still green, and some of them were still in bloom at digging time. These were given a rating of 4.

At harvest time all varieties were also rated as to the apparent degree of injury caused by the disease to the vines and to the tubers. All plants showed typical symptoms of the disease, so a value of 1 was assigned to those showing the least injury and a value of 5 to those most seriously injured.

In 1938, 20 varieties representing early, midseason, late, and very late types were planted to test their relative tolerance to the effect of psyllid yellows. All varieties were planted at random in each of 4 blocks with 3 plots of each variety in each block, making a total of 12 plots of each variety. Two of these blocks were sprayed to control psyllid yellows and the other 2 were not sprayed. Liquid lime-sulphur at the rate of 1 gallon to 40 gallons of water was used on the sprayed plots. The planting was made about the 5th of May. Two varieties (Perfect Peachblow and Vermont Viking) were rogued from the test because of virus diseases, and another (Green Mountain) was discarded as being untrue to type.

The work in 1939 was designed to determine whether the greater yields of the early varieties were due to tolerance to the psyllid yellows disease or whether they escape the full effects of the disease by setting their tubers before being attacked by psyllids. For this purpose three varieties (Cobbler, Bliss Triumph, and Katahdin) were selected for study as they represent fairly well the early, early to midseason, and late varieties that can be grown in the Cheyenne area. The field layout consisted of a split-plot design. There were six large blocks each of

which was divided into 8 sub-blocks. At approximately 10-day intervals from the 25th of April to the 3d of July, one sub-block in each block was planted with the three varieties arranged at random. The sub-blocks were also randomized. Three large blocks (chosen at random) were sprayed. The remaining 3 blocks were not sprayed.

Insofar as could be determined a perfect control of psyllid yellows was secured in the sprayed blocks, whereas all plants in the unsprayed blocks showed typical and severe symptoms of the disease. All plots were rogued twice during the summer to remove, as completely as possible, all plants infected with other diseases. However, plants found to be infected with early blight were not rogued, as counts throughout the field showed that the percentage of plants infected was small, and the disease was fairly evenly distributed and not very severe.

Each year data were taken on the yield of U. S. No. 1 and U. S. No. 2 grades and on the culls. To reduce the sizes of the tables the U. S. No. 1 and U. S. No. 2 grades have been combined and presented as the U. S. Commercial grade which represents total yields of marketable potatoes (15).

Differences among varieties are not recognized throughout this paper unless significant by odds of at least 19:1 as determined by application of the t-test for significance.

Results of Variety Tests in 1937

Tests for homogeneity of the error variances of the six series in the 1937 test showed them so variable as to preclude the use of a combined analysis of variance in the reduction of the data. For this reason the unadjusted mean yields, calculated as bushels per acre are given (table 1) together with their standard errors by which the significance of the differences in yields of the varieties may be determined.

The primary interest in this variety test lies in the relative yielding ability and earliness of maturity of the varieties tested under conditions of severe psyllid infestation and no spray protection. In this connection, it is of interest to compare the varieties in the six blocks with their appropriate checks (Irish Cobbler, Bliss Triumph, and Rural New Yorker). These check varieties represent fairly well the early, early to midseason, and late-maturing variety groups.

From such comparisons, it is evident that the check variety Irish Cobbler is one of the best varieties that can be grown under conditions such as existed in this test. It was not exceeded in yield by any variety, whereas 63 varieties yielded less. Twenty-two varieties were not different from it in yields and among these were: Warba, Early White Al-

TABLE I—*Relative yielding ability, earliness of maturity, and psyllid injury of certain potato varieties. Cheyenne, Wyoming, 1937.*

BLOCK A

Varieties	Yields per Acre		Maturity Rating	Degree of Psyllid Injury to	
	U. S. Comm.	S.E. Mean			
	Bu.	Bu.		Tops	Tubers
Cobbler	191	±10	1	4	2
Warba	173	±27	2	5	4
Bliss I[1]	185	±23	2	5	4
Bliss II[1]	166	±48	2	5	4
Bliss III[1]	146	±20	2	5	4
Uncle Sam	126	±20	3	2	4
British Queen	90	±12	3	3	3
Early White Wonder	86	±14	3	3	3
Delaware	87	±25	3	3	4
Early Thoroughbred	94	±12	3	2	4
Katahdin	63	±11	3	3	3
Rural New Yorker	56	±11	3	2	2
Sir Walter Raleigh	48	±18	3	2	3
Russet Burbank	50	±19	3	3	4
Scab Proof Golden Russet	36	±18	3	3	4
Pride of Wisconsin	44	±20	3	3	3
McKinley	31	±15	3	3	3
Dakota Red	6	± 3	4	2	5

BLOCK B

Varieties	Yields per Acre		Maturity Rating	Degree of Psyllid Injury to	
	U. S. Comm.	S.E. Mean			
	Bu.	Bu.		Tops	Tubers
Early White Albino	281	± 9	1	3	2
Green Mountain	279	±14	3	3	2
Cobbler	270	±16	1	3	1
Bliss I[1]	257	±16	2	4	4
Early Snowflake	237	±11	1	3	2
Bliss T. (Very Early)[2]	227	± 6	2	4	4
Trustbuster	227	± 4	1	3	2
Bliss T. (Med. Early)[2]	229	±20	2	4	4
Bliss T. (Early)[2]	242	±16	2	4	4
Bliss III[1]	206	±10	2	4	4
Burpee's Extra Early	194	±20	1	3	3
Bliss II[1]	209	±12	2	4	4
Bliss T. (Late)[2]	184	±32	2	4	4
Blue Victor	190	±22	2	3	3
Prosperity	186	±28	4	2	4
Arran Banner	157	±31	4	2	3
Rural New Yorker	142	±22	3	2	2
Earliest of All	133	± 8	3	3	2
Robson Seedling	88	±14	4	2	2
White Star	67	± 6	4	2	5

TABLE 1—*Relative yielding ability, earliness of maturity, and psyllid injury of certain potato varieties. Cheyenne, Wyoming, 1937. (Continued).*

BLOCK C

Varieties	Yields per Acre		Maturity Rating	Degree of Psyllid Injury to	
	U. S. Comm.	S.E. Mean		Tops	Tubers
	Bu.	Bu.			
Cobbler	269	±13	1	3	2
Early Surprise	237	±18	1	3	2
Bliss III[1]	257	±29	2	5	4
Bliss I[1]	255	±20	2	5	4
Burbank	241	±18	3	2	4
Bliss II[1]	216	±13	2	5	4
White Gold	202	±14	1	3	3
Early Ohio	189	±21	1	3	3
Early Idaho	156	±32	1	3	3
Rural New Yorker	154	±23	3	2	2
Dibbles Russet	168	±12	3	2	2
Chippewa	147	±26	3	3	3
Gold Coin	173	±38	2	2	4
Carman No. 3	135	±25	3	2	3
Early Six Weeks	116	±30	1	4	3
Sequoia[3]	68	± 7	4	1	5
Golden	110	±28	3	2	5
Brown Beauty	99	±12	3	2	4
C. S. 1221[4]	83	±14	3	2	5

BLOCK D

Varieties	Yields per Acre		Maturity Rating	Degree of Psyllid Injury to	
	U. S. Comm.	S.E. Mean		Tops	Tubers
	Bu.	Bu.			
C. S. 458[4]	337	±22	3	3	2
C. S. 528[4]	320	±24	1	2	3
Cobbler	295	±25	1	3	2
C. S. 416[4]	271	±25	2	4	2
C. S. 474[4]	232	±26	2	3	2
Bliss I[1]	233	±27	2	4	4
Bliss II[1]	231	±29	2	4	4
Salzer's Earliest	230	±23	2	4	4
Bliss III[1]	227	±10	2	4	4
Pure Early Rose	217	±13	2	3	3
Rural New Yorker	157	±16	3	2	2
C. S. 891[4]	160	±30	3	2	4
Peachblow	161	±14	3	2	4
Russet Rural	124	±19	3	2	2
Perfect Peachblow	120	±20	3	2	5
C. S. 1009[4]	119	±16	3	4	3
C. S. 1012[4]	98	±21	3	3	4
Vermont Viking	84	±17	4	2	4
Spaulding Rose	53	± 8	4	3	5
Rust Proof	46	±15	4	2	5

TABLE 1—*Relative yielding ability, earliness of maturity, and psyllid injury of certain potato varieties. Cheyenne, Wyoming, 1937. (Continued).*

BLOCK E

Varieties	Yields per Acre		Maturity Rating	Degree of Psyllid Injury to	
	U. S. Comm.	S.E. Mean		Tops	Tubers
	Bu.	Bu.			
Cobbler	335	±22	1	3	1
C. S. 565[4]	320	±42	2	2	3
Bliss II[1]	255	±45	2	4	4
Minn. 1.33-1-34[5]	240	± 9	1	3	2
Bliss III[1]	238	±28	2	4	4
Bliss I[1]	224	±21	2	4	4
Minn. 5.33-1-34[5]	220	± 8	2	4	3
Minn. 29.32-1-34[5]	217	±20	2	3	3
C. S. 1448[4]	169	±17	1	3	2
C. S. 453[4]	214	±15	3	3	2
C. S. 1111[4]	184	±16	2	2	3
C. S. 1432[4]	199	± 9	2	2	3
Minn. 30.33-1-34[5]	144	±27	2	5	2
C. S. 869[4]	143	± 7	2	2	3
Rural New Yorker	108	±15	3	2	2
Minn. 4-25-12[5]	106	±12	4	4	4
Minn. 4-25-13[5]	107	±18	4	3	4
Minn. 40-2-2-1[5]	80	±12	3	3	4
Minn. 11-1-2-1[5]	64	±12	3	4	4
Minn. 4-25-6[5]	53	±11	4	4	5

BLOCK F

Varieties	Yields per Acre		Maturity Rating	Degree of Psyllid Injury to	
	U. S. Comm.	S.E. Mean		Tops	Tubers
	Bu.	Bu.			
Cobbler	225	±24	1	3	1
Earlaine	201	±22	2	3	3
Minn. 32.31-2-33[5]	186	±26	1	4	2
Bliss III[1]	190	±22	2	4	4
Minn. 4-53[5]	204	±18	3	3	2
Bliss I[1]	181	±23	2	4	4
Bliss II[1]	182	± 5	2	4	4
Minn. 116.30-1[5]	191	±16	4	3	2
Minn. 38.31-3-33[5]	167	±20	4	4	3
Minn. 4-25-26[5]	171	±23	4	4	3
Minn. 32.31-3-33[5]	167	±21	4	3	3
Rural New Yorker	144	±12	3	2	2
Houma	158	±18	4	3	3
U.S.D.A. 46110[6]	70	± 4	3	2	5
Minn. 41-2-12-1-1-1[5]	77	±19	4	3	3
U.S.D.A. 46125[6]	43	±14	4	3	4

TABLE 2—*Mean yields of sprayed plots of 17 varieties of potatoes at Cheyenne, Wyoming, in 1938, and top injury as a result of psyllid yellows in similar, but unsprayed, plots.*

Varieties	Yields in Bushels per Acre				Maturity Rating	Degree of Psyllid Injury to Tops in Unsprayed Plots
	U. S. Comm.	S. E. Mean	Culls	S. E. Mean		
	Bu.	Bu.	Bu.	Bu.		
Early Snowflake	178	±28	42	± 5	1	5
Early Ohio	146	±26	31	± 2	1	5
Cobbler	130	±19	29	± 5	1	5
Chippewa	126	±13	47	± 5	3	3
Warba	106	±22	34	± 4	2	5
Burpee's Extra Early	91	± 6	24	± 2	1•	5
Early Six Weeks	90	±17	29	± 6	1	5
Bliss Triumph	89	±19	75	± 7	2	5
Burbank	51	±10	39	± 7	3	3
Gold Coin	45	±17	36	± 7	2	3
Katahdin	45	±12	17	± 3	3	3
Houma	38	±11	37	± 3	4	4
Rural New Yorker	23	± 7	10	± 2	3	4
Golden	18	± 6	31	± 7	3	4
Brown Beauty	16	± 6	23	± 1	3	3
Spaulding Rose	9	± 4	14	± 4	4	3
Rust Proof	0.66	±0.48	4	± 1	4	1

[1]Bliss Triumph obtained from certified stock of Nebraska Agricultural Experimet Station.

[2]Strains of Bliss Triumph selected by the Nebraska Agricultural Experiment Station, for different seasons of maturity.

[3]Seedlings obtained from the North Carolina Agricultural Experiment Station.

[4]Seedlings obtained from the Colorado Potato Experiment Station.

[5]Seedlings and native South American varieties obtained from the Minnesota Agricultural Experiment Station.

[6]Seedlings obtained from United States Department of Agriculture.

bino, Green Mountain, Early Snowflake, Burbank, Earlaine, and the "Early" and "Medium Early" Nebraska strains of Bliss Triumph. The yields of the strain of Bliss Triumph used as a check variety did not differ from those of Irish Cobbler in blocks A, C, and F but yielded less than Irish Cobbler in blocks B, D, and E.

Bliss Triumph, too, ranked high among the varieties tested. Only 4 varieties (Early White Albino, Green Mountain, C. S. 458 and C. S. 528) produced greater yields. Thirty-six varieties were not different from Bliss Triumph, and 44 yielded less. A comparison of its yields with those of Irish Cobbler is given in the preceding paragraph.

Rural New Yorker ranked rather low among the varieties in yield of

marketable tubers: Thirty varieties exceeded it, 44 were not different, and only 11 produced less.

From the comparisons just made, it appears that Irish Cobbler is one of the best varieties that can be grown under conditions of severe psyllid infestation and where spray protection is impracticable. Bliss Triumph also ranks high in yield among the varieties tested, but it also produces a relatively high proportion of the smaller and cull grades. A possible explanation for the high production of the smaller sized tubers may be found in the relatively great degree of injury caused by the disease to both the tops and tubers of this variety (table 1). Rural New Yorker ranks fairly low in the production of the larger sizes of tubers, but it also ranks fairly low in the production of culls. This low production of culls is in keeping with the relatively smaller degree of top and tuber injury shown by this variety.

Direct comparisons cannot be made between the yields of varieties in different series. By referring to Figure 1 you will understand why this cannot be done. In this figure the yields of the check varieties Irish Cobbler, Bliss Triumph, and Rural New Yorker are shown for each of the six blocks. The average for all check plots is shown as a broken line.

It will be noted that the average yields for block A are low and that they increase in block B and are held about constant through C, D and E. In F the average yields decrease again but are not so low as in A. An exception to this average trend is found in Rural New Yorker in block F where its yield is slightly higher than in E. However, this difference does not reach significant proportions.

The reason for the wide differences in yields among the several blocks is not definitely known. They can hardly be caused by soil differences as the blocks were relatively narrow, and well replicated tests with other crops on the same piece of ground both before and subsequent to the work reported here fail to show such variability. The most logical explanation seems to be that the psyllid usually migrates into tomato and potato fields around the margins. This is especially true in those cases where adjacent areas contain vegetation less well suited to their needs than the crops mentioned. In the present instance there was a shelterbelt of cottonwood trees on both the east and west sides of the potato plots, nearer to A and F, especially, than to the other blocks. Moreover, the shelterbelt on the west was closer to block A than the eastern shelterbelt was to block F. These shelterbelts, with the inevitable growth of various types of vegetation around and under the trees, would furnish an ideal place for the hibernation of the psyllids and

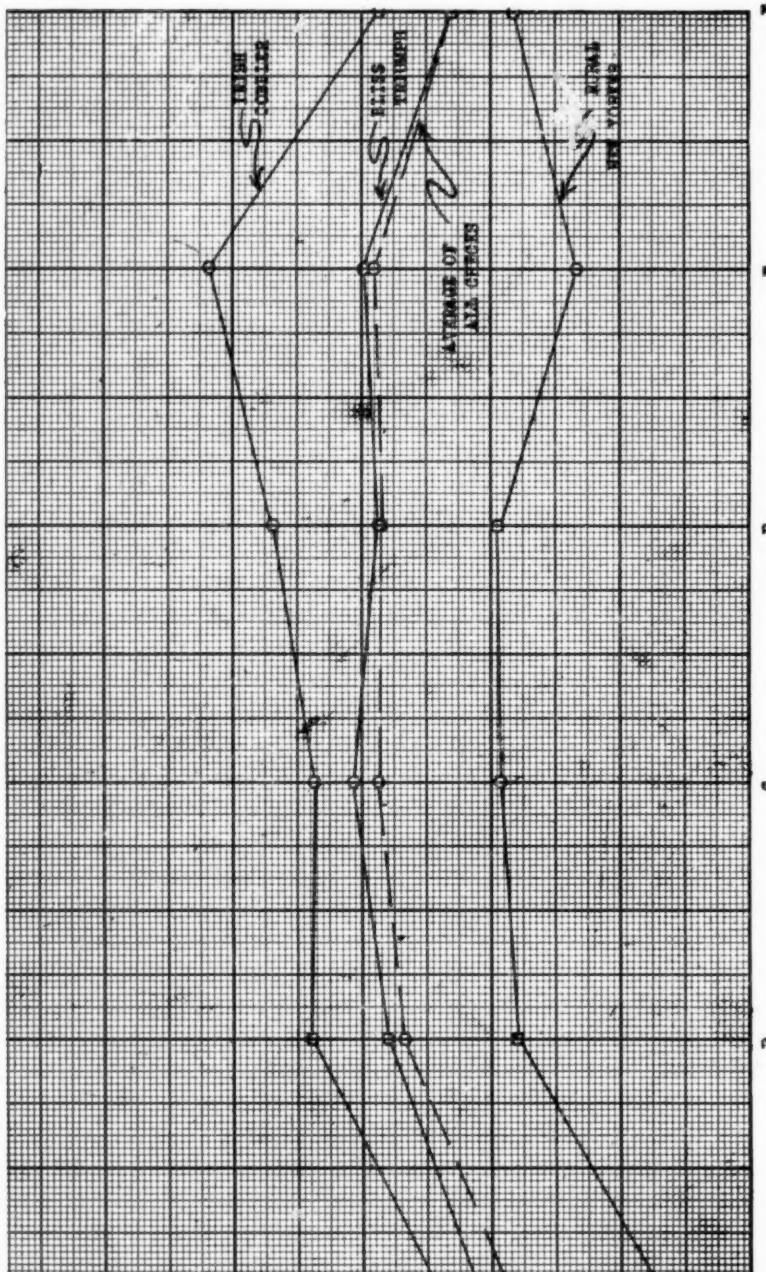

FIGURE 1.—Average Yields of Commercial Grade Potatoes by the Check Varieties. 1937.

may have served as a focal point for the infestation of the potato plots. Under such conditions it is natural that the infestation of psyllids would be heavier in blocks A and F than in those more centrally located.

Whatever the cause of the differences the check plots show that the variability of yields among the several blocks cannot be ignored. For example, table 1 shows a difference of 108 bushels between Warba in block A and Early White Albino in block B. Had both varieties been grown in the same block, no doubt this difference would have been considered significant. However, the average yield of the three check varieties in block A was 68 bushels less than the average of these same varieties in block B. Obviously, therefore, Warba in A cannot be compared with Early White Albino in B, except through the yields of the check varieties in the two blocks.

Hayes and Immer (*7*) have given a formula for making such comparisons in those cases where more than one check has been included in each test[5]. However, because of the large number of varieties involved, comparisons of varieties grown in different blocks will not be presented.

Correlation between Yields, Earliness of Maturity, Apparent Tuber Injury, and Apparent Top Injury

Correlation studies[6] at time of harvest between (1) yields, (2) time of maturity, (3) apparent degree of psyllid yellows disease injury to the tubers, and (4) apparent degree of injury to the tops of the plants showed that earlier maturing varieties, as a group, had greater apparent signs of top injury and less apparent signs of tuber injury, and produced higher yields than did the later maturing varieties.

Greater apparent tuber injury was associated with lower yields,

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[5]By this method comparisons may be made of $(A - \overline{ch}_1) - (B - \overline{ch}_1)$, where $\overline{ch}_1$ and $\overline{ch}_2$ are the means of the several checks appropriate to the respective varieties. The standard error of this difference will be

$$\sqrt{\left(S_1^2 + \frac{S_1^2}{N}\right) + \left(S_2^2 + \frac{S_2^2}{N}\right)}$$

where S_1^2 and S_2^2 = variance of the mean for a single variety in series 1 and 2, respectively, and N = number of checks used in each block, which in the present instance is 5. Tested by this formula, the difference in yield between Warba in Block A and Early White Albino in block B is non-significant. Although use of this formula for making such comparisons appears to give thoroughly conservative results, there are biological reasons for not making too close comparisons in this manner. To make them it must be assumed that had the varieties being compared been grown in a different block from that in which they actually were grown they would have varied in yield in the same manner as the check varieties in the two blocks involved. Such an assumption does not always appear to be fully justified.

and greater apparent top injury with higher yields. However, this latter correlation became non-significant when the effects of earliness of maturity and tuber injury were eliminated. It logically follows that the correlation between apparent top and tuber injury was non-significant.

The inter-relationship of these factors provides an insight into the manner by which the psyllid yellows disease produced its effects on potatoes. Psyllid infestation takes place with great rapidity and thus the psyllid yellows disease attacks varieties of the early, midseason, and late-maturing varieties of potatoes at different stages of physiological maturity. When the disease attacks them after tuber formation is well advanced its effects on yields are not so serious as they are when it attacks them before tuber formation has been initiated or during the early stages of tuber formation. In the latter case tubers that have set show severe symptoms of the disease; or, if they have not started to set, normal tuber formation is inhibited. With respect to the vines, the apparent effects of the disease are more pronounced on the early-maturing varieties than on the late varieties because at the time of attack they are physiologically more mature and declining in vegetative vigor. Under such conditions the effects of the psyllid attack appear more pronounced than they would if the plants were younger and more vegetative.

Despite the high significance of the correlation between earliness of maturity and yields, it is evident (table 1) that there are exceptions to the general rule that the earlier maturing varieties produced higher yields than those maturing later. Of particular interest in this study are those varieties which, though later maturing than the checks, nevertheless produced equal or higher yields.

Thus 6 of the 22 varieties not differing from Cobbler in yield, namely, Warba, C. S. 416, C. S. 474, Salzer's Earliest, C. S. 565, and Earlaine, were given a maturity rating of 2; 4 varieties, Green Mountain, Burbank, C. S. 458, and Minn. 4-53, were given a maturity rating of 3; and 5 varieties, Minn. 116.30-1, Minn. 38.31-3-33, Minn. 4.25-26, Minn. 32.31-3-33, and Houma, were given a maturity rating of 4.

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[6]Simple and partial correlation between (1) yields of U. S. commercial grade potatoes, (2) time to maturity, (3) apparent degree of injury to tubers, and (4) apparent degree of injury to the tops.

Simple Coefficients		Partial Coefficients	
r_{12}	—.6279**	$r_{12.34}$	—.4880**
r_{13}	—.4796**	$r_{13.24}$	—.3088**
r_{14}	+.2496*	$r_{14.23}$	+.1263
r_{23}	+.4332**	$r_{23.14}$	+.2172*
r_{24}	—.2935**	$r_{24.13}$	—.2061*
r_{34}	—.0328	$r_{34.12}$	—.0701

*Exceeds the 5-per cent point.
**Exceeds the 1-per cent point.

Of the 4 varieties exceeding Bliss Triumph in yield, 2 varieties (Green Mountain and C. S. 458) were given a maturity rating of 3. Of the 36 varieties not differing from it in yields, 5 varieties (Uncle Sam, Burbank, C. S. 891, C. S. 453, and Minn. 4-53) were given a maturity rating of 3, and 7 varieties (Prosperity, Arran Banner, Minn. 116.30-1, Minn. 38.31-3-33, Minn. 4-25-26, Minn. 32.31-3-33, and Houma) were given a maturity rating of 4.

Rural New Yorker was exceeded in yield by 30 varieties. Of these, 1 variety (Minn. 116.30-1) was given a maturity rating of 4. Forty-four varieties were not different from Rural in yield, and 9 of these (Prosperity, Arran Banner, Robson Seedling, Minn. 4-25-12, Minn. 4-25-13, Minn. 38-31-3-33, Minn. 4-25-26, Minn. 32.31–3–33, and Houma) were given a maturity rating of 4. Although the earlier maturing varieties, as a group, produced higher yields than those maturing later, high yielding ability was not always associated with earliness of maturity nor were low yields always associated with lateness of maturity (even for varieties given a maturity rating of 3 or 4).

Tolerance Studies on 17 Potato Varieties—1938

Psyllid infestation was exceptionally heavy in 1938, but no symptoms of the psyllid yellows disease were found in the sprayed series until toward the latter part of August. This outbreak was caused by a late infestation after the last spray was applied on the 9th of August. How much this affected yields in the sprayed plots is not known, but the apparent injury to the tops was slight and none was apparent in the tubers. In the unsprayed blocks no tubers of marketable or usable size were produced. As these same varieties were grown in 1937 and produced potatoes though unprotected by spray, it is evident that the effects of the disease were much more severe in 1938 than in 1937. Yield data on the sprayed blocks are presented in table 3 as mean yields per acre together with their standard errors. The last column of the table shows the relative top injury to the 17 varieties in the unsprayed plots.

The yields of all varieties were relatively low, perhaps as a result of the late infestation of psyllids. However, as all varieties were planted early and tuber formation began on most varieties some time previous to the late infestation, it is unlikely that the low yields were due entirely to this factor.

In this test Cobbler was not exceeded in yields of U. S. Commercial potatoes by any variety, but the yields of 10 varieties were not different. Three of these 10 varieties (Warba, Bliss Triumph, and Gold Coin) had a maturity rating of 2 and 3 of them (Chippewa, Katahdin

and Burbank) had a maturity rating of 3 and were thus definitely later than the others in maturing.

Bliss Triumph produced very low yields of tubers, but because all yields were low no variety produced more. Fourteen of the 16 varieties were not different from Bliss Triumph in yield. Of these, 6 varieties (Chippewa, Katahdin, Burbank, Rural New Yorker, Brown Beauty, and Golden) were given a maturity rating of 3, and 1 (Houma) a rating of 4.

Rural New Yorker was exceeded in yield by 5 varieties (Early Snowflake, Early Ohio, Cobbler, Chippewa, and Burpee's Extra Early). However, its yields were so low that no variety could be demonstrated as yielding less.

In confirmation of the results obtained in 1937, it will be noted that, in general, it was the earliest-maturing varieties that produced the highest yields and that showed the greatest apparent degree of top injury in the unsprayed series. The explanation for this apparently contradictory relationship between top injury and yields has already been given (p. 332).

Perhaps the most important single result of the 1938 study is the finding that in years of very severe psyllid infestation none of these varieties was able to produce a crop unless protected by spray though it has been demonstrated that in years of lighter psyllid infestation several of them produce fairly satisfactory crops even without spray protection.

Influence of Date of Planting and of Spraying for Psyllid Yellows Control on Yields of Three Potato Varieties, 1939.

In previous tests designed to determine whether there are potato varieties tolerant to psyllid yellows, it was found that the earlier maturing varieties, as a class, were more productive than those that matured later. However, under normal conditions, and when the psyllid yellows disease is not a factor, certain of the late varieties in group 3 (table 1) produce as well as those in the first-early group. This shows that the ability to yield is not necessarily directly related to time of maturity and suggests that other factors may be involved. Thus, the effects of the disease may be more or less serious depending on the physiological stage of maturity of the plants when the psyllid infestation takes place. Should this be so, then the earlier-maturing varieties might escape the full effects of the disease by setting their tubers before being infested with psyllids. It was also considered possible that certain of the earlier-maturing varieties might possess a measurable degree of tolerance to the disease regardless of the stage of maturity at which they were infested by psyllids.

To test these theories Cobbler, an earlier variety, Bliss Triumph,

TABLE 3—*Influence of date of planting and of spraying for psyllid yellows control on yields of Cobbler Potatoes, Cheyenne, Wyoming, in 1939.*

Date of Planting	U. S. Commercial Grade Potatoes				Culls			
	Sprayed	S. E. Mean	Unsprayed	S. E. Mean	Sprayed	S. E. Mean	Unsprayed	S. E. Mean
	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.
April 25	102	± 9.07	42	± 9.56	17	± 3.43	40	± 1.86
May 5	101	±10.19	45	± 4.00	20	± 2.87	44	± 3.74
May 15	122	± 9.80	41	± 8.86	9	± 1.52	32	± 1.88
May 25	136	±10.85	41	±10.72	10	± 4.00	29	± 1.71
June 4	135	± 6.90	53	±12.07	5	± 0.53	16	± 2.11
June 14	125	± 9.54	41	± 8.57	9	± 1.38	17	± 1.76
June 24	93	± 8.73	17	± 4.27	10	± 0.67	22	± 1.56
July 3	53	±10.56	2	± 1.50	8	± 1.20	5	± 1.73

TABLE 4—*Influence of date of planting and of spraying for psyllid yellows control on yields of Bliss Triumph Potatoes, Cheyenne, Wyoming, in* 1939.

Date of Planting	U. S. Commercial Grade Potatoes				Culls			
	Sprayed	S. E. Mean	Unsprayed	S. E. Mean	Sprayed	S. E. Mean	Unsprayed	S. E. Mean
	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.
April 25	66	±10.85	26	± 5.22	43	± 2.81	69	± 6.69
May 5	67	± 7.57	34	± 9.04	34	± 3.12	58	± 3.06
May 15	96	±13.16	26	± 6.16	22	± 3.11	57	± 3.19
May 25	107	±19.63	23	± 9.71	16	± 1.39	50	± 4.15
June 4	101	±15.59	29	± 8.77	13	± 1.47	30	± 3.39
June 14	73	±11.07	19	± 3.63	15	± 1.70	26	± 1.94
June 24	41	± 6.80	4	± 2.06	12	± 1.21	14	± 1.34
July 3	24	± 7.15	1	± 0.42	16	± 2.90	11	± 3.16

TABLE 5—*Influence of date of planting and of spraying for psyllid yellows control on yields of Katahdin Potatoes, Cheyenne, Wyoming, in* 1939.

Date of Planting	U. S. Commercial Grade Potatoes				Culls			
	Sprayed	S. E. Mean	Unsprayed	S. E. Mean	Sprayed	S. E. Mean	Unsprayed	S. E. Mean
	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.
April 25	241	±11.66	19	± 7.47	24	± 1.22	36	± 5.71
May 5	246	±27.79	21	± 5.50	18	± 1.27	38	± 3.28
May 15	196	±20.52	14	± 5.93	14	± 2.17	22	± 2.75
May 25	169	± 3.37	12	± 4.52	15	± 1.65	25	± 3.86
June 4	138	±11.41	18	± 7.18	18	± 2.44	23	± 4.01
June 14	111	±11.12	15	± 3.76	17	± 2.07	24	± 4.26
June 24	55	± 5.00	0.87	± 0.39	31	± 1.27	12	± 2.47
July 3	25	± 4.77	0.10	± 0.10	21	± 2.85	3	± 1.66

an early to midseason variety, and Katahdin, representing the latest-maturing varieties that can be grown at Cheyenne, were planted on 8 successive dates from the 25th of April to the 3d of July, 1939, inclusive. One-half of the plots were sprayed to control the psyllids and the remainder were left unsprayed. With such an experimental design, the presence or absence of tolerance should be indicated by the yields from the sprayed and unsprayed plots for the several planting dates. The results of these tests are shown in tables 3, 4, and 5.

Highly significant differences occurred in yields from the sprayed plots for the several planting dates. However, there were also considerable differences among the varieties in their response to date of planting. Thus, with Cobbler and Bliss Triumph (tables 3 and 4) the best yields were produced by plantings made near the middle of the range in planting dates, or those made on May 15, May 25, June 4, and June 14. With Katahdin (table 5), on the other hand, there was no difference in yields between the plantings made on the 25th of April and 5th of May, but yields from plantings made on these dates were greater than those from plantings made on any of the other dates. In other words, the highest yields were made by Katahdin from the early plantings and consistently decreased as planting was delayed. Yields for all three varieties were low from plantings made on the 24th of June and the 3d of July, and it appears evident that such late plantings did not give sufficient time for the production of anything like normal yields.

The effects of the disease on yields in the unsprayed plots were such that there were no differences among yields from the earlier plantings and those made between the 25th of April and the 14th of June, inclusive. Yields from these earlier plantings were, with a few unimportant exceptions, greater than those from plantings made the 24th of June and the 3d of July. It appears probable, however, that the yields from these last two plantings were lowered by lateness of planting, as well as by the effects of the disease.

The data show that the yields from the unsprayed plots of Cobbler are from 30 to 45 per cent of those from the sprayed. Yields from plantings made on the 24th of June and the 3d of July are omitted from this and subsequent comparisons, because they cannot be considered as normal. The Bliss Triumph yields from the unsprayed plots varied from 22 to 51 per cent compared with those from the sprayed. In contrast with those of Cobbler and Bliss Triumph, the yields from the unsprayed plots of Katahdin varied only 7 to 14 per cent compared with those from the sprayed.

Such comparisons indicate that Cobbler and Bliss Truimph possess a low yet measurable degree of tolerance to psyllid yellows. Had there been a total absence of tolerance their yields from the unsprayed plots

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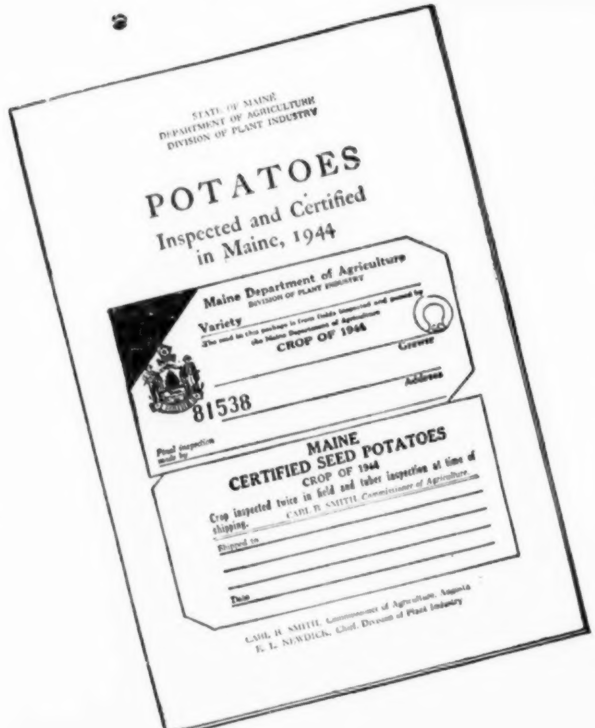

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would have been as low or lower than those of Katahdin. Moreover, if the high correlation found between earliness of maturity and yielding ability was due to early setting of tubers and consequent escape from the full effects of the disease, there should be considerable variation among the yields from the unsprayed plots for the several planting dates. Such variations are not found in the yields of Cobbler or Bliss Triumph whose yields were sufficiently large to show such variation. In the case of Katahdin the yields were so low that very little variation was possible.

Discussion and Summary

A preliminary test of 56 commercial varieties and 182 seedling selections and South American varieties made in 1936 (1) showed that none of them was immune from psyllid yellows. However, as there were considerable differences among them in their yielding abilities, it appeared possible that there were differences among them in their tolerance to the effects of the disease. This test also indicated that there was a positive association between earliness of maturity and yielding ability, but the evidence was not conclusive.

A second varietal test was made in 1937 which included 53 commercial varieties and 34 seedling selections. As in the first test, all varieties showed typical and severe symptoms of the disease.

Correlation studies were made of the relation between such factors as time to maturity, apparent signs of tuber injury, apparent signs of top injury and yields. These studies indicated that the earlier maturing varieties, as a group, showed greater apparent signs of top injury, less apparent signs of tuber injury, and produced greater yields than the later maturing varieties. The correlation between apparent top injury and yields became non-significant when the effects of earliness of maturity and tuber injury were eliminated.

Of the 86 varieties and seedling selections included in the test, none exceeded Cobbler in yields but 22 varieties were not different. Bliss Triumph was exceeded in yield by 4 varieties, and 36 varieties were not different. It is apparent, therefore, that Cobbler and, to a lesser degree, Bliss Triumph are among the best varieties that can be grown under conditions where it is impracticable to spray for psyllid control.

Despite the highly significant correlation between early maturity and high yields, there were several important exceptions to the general rule that the earlier-maturing varieties produced greater yields. Thus, of the 22 varieties not differing from Cobbler in yields, 15 were definitely later in maturing; of the 4 varieties exceeding Bliss Triumph, 2 were later maturing; and of the 36 not differing from it, 12 were later maturing. These later-maturing but high-yielding varieties are of par-

ticular interest as they demonstrate that high yields are not always associated with early maturity or low yields with late maturity.

Tests in 1938 included 17 varieties representing the early, midseason, late, and very late types. One-half of the plots were sprayed to control psyllid yellows and the remainder were left unsprayed. The psyllid infestation was exceptionally heavy and none of the varieties produced tubers of marketable or even usable size in the unsprayed plots. This demonstrated that none of them possessed a measurable degree of tolerance in a "test" year unless protected by spray. However, it did not prove that some of them might not possess a measurable degree of tolerance in average years, or years when the psyllid infestations should be less heavy. In this connection it is of interest to note that 6 of these 17 varieties (Cobbler, Warba, Bliss Triumph, Burbank, Houma, and Rural New Yorker) were grown in the 1937 tests and produced appreciable yields even though not protected by spray. Cobbler, moreover, has been reported as showing signs of tolerance to the disease (6). This test also failed to demonstrate whether the seeming tolerance of certain of these varieties in more favorable years was due to true tolerance or whether they escaped the full effects of the disease through the relationship between time of psyllid infestation and the physiological stage of maturity of the plants at the time of psyllid infestation.

The work in 1939 was designed primarily to determine whether certain potato varieties sometimes escape the full effects of psyllid yellows by virtue of setting their tubers at a time when they are not so seriously injured or if they possess a measurable degree of true tolerance.

Yields from the sprayed plots indicate that the earlier planting dates were more favorable to Katahdin, whereas, for Cobbler and Bliss Triumph the highest yields were secured from plantings made near the middle of the range in planting dates. With all three varieties, however, there were highly significant differences among the yields for the several planting dates thus demonstrating that when psyllids are controlled time of planting has an important influence on yields. All three varieties produced very low yields from plantings made on the 24th of June and the 3d of July and it appears evident that such late plantings did not give sufficient time for them to produce anything like normal yields.

Both the absolute magnitude of the yields from the unsprayed plots of Cobbler and Bliss Triumph and the relative magnitude of these yields as compared with those from the sprayed plots indicate that these two varieties possess a measurable degree of tolerance to psyllid yellows. In the total absence of tolerance their yields would have been as low as or lower than those of Katahdin. Furthermore, the lack of variation

among the yields from the unsprayed plots of Cobbler and Bliss Triumph for the several planting dates also indicates a certain degree of tolerance. Had the high correlation found between yielding ability and earliness of maturity been due to early tuber formation and consequent escape from the full effects of the disease, there would have been considerable variation among the yields for the several planting dates. In other words, the yields from some of the earlier plantings should have been much greater than those from later plantings. Such was not the case if the yields from plantings made on the 24th of June and the 3d of July are omitted from the comparisons and it is evident that these yields should be omitted as such late plantings did not produce normal yields even in the sprayed plots. From these results it is apparent that Cobbler and Bliss possess only a very low degree of tolerance, and the evidence furnished by the 1938 data shows that it is not a measurable degree in years of exceptionally heavy psyllid infestation. However, in what might be called more nearly normal years these two varieties as well as some of the higher-yielding varieties in the 1937 tests can be expected to produce fair yields even without spray protection, and are the ones recommended for planting in this region wherever such protection is not possible.

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POTATO FERTILIZATION AND NUTRITION STUDIES IN 1943[1]

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Results of investigations published largely in 1943 and early in 1944 on fertilizers, fertilization, minor elements, absorption of nutrients, methods and time of fertilizer placement, liming and soil reaction with reference to the potato are summarized briefly. Certain references which have not been reviewed in this paper are included with the literature citations for those who desire a fairly complete bibliography on this subject.

FERTILIZER PRACTICES

Davies and Fagan (13) found that potato haulms grown on acidic bracken land in England have an exceptionally low calcium content of the stem and leaf. There is a four-fold increase in concentration of Ca after application of calcium carbonate to the soil. Simultaneously with the large increase in concentration of CaO there is a smaller but appreciable increase in concentration of phosphoric acid in both stem and leaf. Where fertilizers are applied to these bracken areas in the absence of ground limestone, they have little, if any, effect on the yield of the tubers, unless Ca is a constituent of them, but mixtures supplying the plant with Ca have a very appreciable effect. Phosphoric acid has the greatest effect on yield in the presence of ground limestone. Nitrogen and potash effect a further improvement in yield where adequate quantities of limestone and phosphoric acid have been included. Potatoes grown on the bracken areas contain less dry matter but more N than those grown on the adjacent lowlands. The greatest effect on the maturity of the tubers has been produced by the application of limestone followed by a complete fertilizer consisting of ammonium sulphate and potassium chloride.

Carolus (8) conducted experiments on a sassafras sandy loam on the Eastern Shore of Virginia which indicated that after dry seasons in which much of the applied N is not utilized by the plant but is prevented from leaching by green manure cropping, a reduction in the amount of N applied for potatoes is highly desirable. On acid soils large quantities of phosphorus in potato fertilizers are apparently necessary, regardless

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of previous weather conditions, until the P-fixing capacity of the soil is adequately satisfied. Calcium does not appear to be an important factor in the growth and yield of potatoes. Brown (3) found that under continuous culture for six years on Merrimac fine sandy soil, maximum yields of potatoes were obtained from annual applications of N 100 P_2O_5 80 and K_2O 120 pounds per acre. Addition of carriers of calcium, magnesium, sodium, manganese, zinc, boron and chlorine to a fertilizer containing only N, P, and K did not increase the yields. Cordner (12) working in Oklahoma on a light sandy soil found that 600 pounds of 4-8-4 per acre is about the right amount of fertilizer for potatoes. Production was not increased by the application of more than 24 pounds K_2O to the acre. Smith (41) discussed the methods of getting the most from a fertilizer for potatoes including the organic matter content of the soil, correctly balanced fertilizers, quantity of fertilizer needed, methods of applying fertilizers, soil reaction and more efficient use of manure.

Nitrogen

Brown (5) states that in 27 field tests on six soil types in Maine, New York, Pennsylvania, and Virginia a slightly but not significantly higher average yield of potatoes was obtained with ammonuim nitrate than with either ammonium chloride, ammonium sulphate, ammonium nitrate or urea. For all the experiments the weighted average yield for NH_4NO_3 was 241, the highest; and for $NaNO_3$, 232, the lowest bushels per acre. Brown (4) compared NH_4NO_3 with $(NH_4)_2SO_4$, NH_4Cl, $NaNO_3$ and urea in 27 field tests. The net results showed that NH_4NO_3 rated first, although the yield increase over the other materials was comparatively slight.

Phosphorus

Gericke (17) has determined the effects of the addition of CaO and (MgO) magnesium oxide separately on P uptake in potatoes in the presence of N as ammonia (NH_3) or (NO_3) nitrate. Potatoes were improved by NH_3. Plants were grown in pots of sandy humus soil of pH 6.5. The basic fertilizer was 2 grams K_2O as (K_2SO_4) potassium sulphate with 1.2 grams N as $(NH_4)_2SO_4$ or $NaNO_3$ together with 0.3, 0.6, 1.2 or 3 grams citrate-soluble P_2O_5 as Thomas slag. To this were added 4.3 grams CaO as $CaCO_3$ or ($CaSO_4$) calcium sulphate; or 3.0 grams MgO as ($MgCO_3$) magnesium carbonate or ($MgSO_4$) magnesium sulphate. With controls, no lime or magnesia, this resulted in 10 series of pots. Deficiency in P is more evident in presence of NO_3 than

of NH_3; however, if P is ample the higher yield results in the presence of NH_3. P uptake but not utilization was increased more in the presence of NH_3 than of NO_3. Ca and Mg salts have but a slight effect on the increase in yield occasioned by P. In the presence of NO_3, Mg decreases yield particularly of potatoes. The advantage of phosphate-nitrate fertilizer disappears in the presence of magnesium (Mg), indicating an antagonism between NO_3 and Mg.

As shown by field experiments by Jacob and Armiger (25) in a number of states, superphosphate made with either clear (H_2SO_4) sulphuric acid or spent acid from the manufacture of high-octane gasoline by the alkylation process, had similar effects on the growth of alfalfa, oats, barley, oat hay, potatoes, silage corn, sweet corn, Sudan grass, sugar beets and wheat. Brown and Hawkins (6) report that superphosphate is a more efficient source of phosphorus for potatoes in Aroostook County than either colloidal phosphate or Tennessee raw rock phosphate. The yields produced by the two latter materials were sometimes no greater than those obtained in the no-phosphorus experiments. The investigation affords definite proof of the need of a readily available source of P_2O_5 in potato fertilizers for Maine. Gericke (16) stated that the solubility of P_2O_5 of rotted stable manure was lower than that of fresh manure and of Thomas-phosphate but higher than that in raw phosphate. Similarly the utilization of the various P acids by the plant was parallel to their solubility. The earlier conception that the P acid of stable manure is superior is, therefore, not valid. The plants used were corn, oats, cabbage, sugar beets, winter wheat, potatoes, barley and turnips.

Potassium

Van der Paauw (33) states that K values showed considerable variation for different K fertilizers and on the type of soils studied no appreciable K reserve was built up. The excess K was, for the most part, washed away, although part remained in the subsoil, where it can still be readily utilized by growing plants. When fertilizing was discontinued, the K value of the top soil dropped quite rapidly to a low level; that of the subsoil dropped less rapidly. The K requirements of cultivated plants vary. Thus, potatoes, rye, and some other crops require a better K supply than oats, which will produce a maximum yield even on quite impoverished soil. Potatoes, spring barley and grass-clover mixtures reacted very unfavorably to an excess of K, while rye, wheat and feed corn profited from a very rich K fertilizing. The form of the N fertilizer used had some effect on the

condition of the K supply. With Chili saltpeter the K value was usually higher than with $(NH_4)_2SO_4$. This was probably the result of greater washing away of the former fertilizer rather than any firmer fixation of the latter. Growing plants did not react to any pronounced degree of these differences. The use of N in the form of nitrate or NH_3 on the soils studied had practically no effect on the K economy of the plants.

Brickley (7) found there was a close correlation between very low potassium (K) availability in the soil, as determined by chemical methods and the incidence of the browning disease of potato foliage. Excess nitrogen (N) in the soil was more potent than excess phosphorus (P) in inducing K-deficiency symptoms in the foliage. Also, development of the disease was favored by applications of P to soils of very low K content but high in N. Browning occurred earlier with consequent reduction in yield when the K fertilizer used in small quantities was broadcast on the soil and harrowed-in before drilling than when it was applied in localized strips near the potato in the drill. Normal potato foliage contained 1.2 per cent K_2O and diseased foliage only about 0.50 per cent. Wallace, *et al* (54) reported that fertilization with Cl-containing K salts caused a marked accumulation of Cl in the foliage and stems of potatoes.

Magnesium, Liming, and Soil Reaction

Wallace *et al* (52) grew potatoes on plots in 1942 on which a fertilizer experiment on black currants had been in progress in the period 1927-'41. No fertilizers were applied to the potatoes. Leaf symptoms of deficiencies of K and Mg were prevalent on the plots, the former where K had not been applied to the currants and the latter where K had been applied. Magnesium-deficiency symptoms were less evident where farmyard manure had been used and where dressings of $MgSO_4$ had been applied in 1940 and 1941. Cooking quality was adversely affected by deficiencies of K and P and these deficiencies were associated with blackening. The highest quality resulted where N was omitted from the otherwise complete fertilizer. Wallace, *et al* (51) state that the incidence of Mg deficiency in potatoes in relation to the fertilizer treatments was correlated with the Mg content of haulm samples from the respective treatments.

Collins and Skinner (11) state that fertilizers formulated to be non-acid-forming with dolomitic limestone gave significantly higher yields of Irish potatoes than did acid-forming fertilizers on coastal plain soils in North Carolina. The non-acid-forming fertilizer main-

tained soil pH at approximately the original level; increased total Mg in the plant and the available Mg in the soil of the root zone; and increased total Ca in the plant with no appreciable change in the ultimate available Ca content of the soil or the K_2O content of the plant, which indicates no appreciable liberation or fixation of the soil and fertilizer K_2O.

Pot and field experiments on liming materials are described by Thun (47). On a soil well supplied with magnesium (Mg) the action of calcined dolomitic limestone on potatoes was unfavorable whereas that of ordinary calcined limestone was favorable. Both materials increased the starch content of the potatoes. The effect of Mg was dependent on the lime status of the soil and was most noticeable on acid soils. Results from Mg are to be expected mainly in plants insensitive to acid since sensitive plants require adequate Ca supplies so that Mg has less effect on such plants. Magnesium sulphate was effective in overcoming Mg deficiency. On sensitive crops on Mg-deficient soils Mg marl was the most advantageous liming material whereas with Ca-loving plants on soils better supplied with Mg as well as with P_2O_5, the more intensively acting ordinary white limestone was superior to the dolomitic limestone. The dolomitic limestone is less soluble than the gray limestone and so has initially less neutralizing action. This difference disappears with time, especially in pot experiments. Maturity was delayed by $MgSO_4$ and by Mg marl but not by calcined dolomitic limestone or calcined limestone. The assimilation of soil P by plants insensitive to acid in an acid soil, low in Mg was favorably affected by $MgSO_4$. Ordinary lime and calcined dolomitic lime had an effect similar to the above on acid-sensitive plants. The uptake of soil K by acid-insensitive plants was improved by $MgSO_4$ but its action on acid-sensitive plants was not favorable as it did not affect the soil reaction. Both types of limestone increased the uptake of soil K. Liming increased the uptake of Mg. This apparently explained the observation of the correction of Mg deficiency through liming as well as the negative effect of magnesia fertilization on limed soils.

Ranninger (35) states that liming of soil of PH 6-7 did not affect the yield or the protein and CaO contents of potato tubers. Watts and Cooper (55) conclude that it is not always practicable to maintain soil reactions capable of producing maximum yields of all crops included in a rotation. Most crops grown on Newtonia silt loam should have a neutral to alkaline reaction, but if some of the crops in the rotation require a slightly acid reaction, a pH as low as 5.5 produces moderate yields. The best compromise pH indicated for Rus-

ton fine sandy loam, when cantaloupes, peas, spinach and tomatoes are grown with snap beans, Irish potatoes and sweet potatoes, is 6.5 to 6.99.

Minor Elements

The relative values of bluestone, oxidized copper ore (10-20 per cent Cu) and roaster residues (1-2.5 per cent Cu, 2-3 per cent Zn) supplying equivalent amounts of Cu for the growth of potatoes were determined by Teakle and Morgan (46). There is a significant improvement in yields with the Cu-containing fertilizers. The Cu ore is most effective for the correction of Cu deficiency. Evidence indicates that on marly swamp soils bluestone is much more effective. A definite response from potatoes was obtained by Staker (42) under field conditions when hydrated lime was added at the rate of 4.9 tons per acre. Neither $Ca(OH)_2$ calcium hydroxide—nor sodium metaphosphate increased the productivity of peat soils containing large amounts of zinc. Leaching with acid, followed by liming to the original pH value, also failed to improve the productivity of these soils. Schropp and Arenz (37) report that sulfur (S) deficient plants are very similar to those with a N deficiency as regards morphology. The S deficiency has a more injurious effect on the yield of those portions of the plant above the ground than on the yield of roots. The supplying of S to potatoes increased the starch content from 10.20 to 11.70 per cent. Sulphur increased the sugar content of sugar beets from 12.96 to 19.68 per cent. Sulphur has a very pronounced effect on the formation of protein. In general, the use of S displaced the ratio of protein N: soluble N considerably in the direction of the protein N.

Numerous pot experiments with sugar beets, spinach, potatoes and oats were conducted on limed and unlimed soils by Keese (29) with background N-P-K fertilization and with or without additions of manganese (Mn) as $MnSO_4 . 7H_2O$ or of boron as H_3BO_3, or of both. The effect of liming and of copper and zinc additions was also studied. Boron increased the sugar content of the beets, especially when lime was applied simultaneously, while the effect of Mn was more often favorable than not. Both B and Mn reduced somewhat the starch content of potatoes. The simultaneous use of Mn and B was superior to either one alone in a few cases. Large applications of lime probably should be avoided as they tend to produce Mn- and B-deficiency symptoms where these symptoms have not previously been observed. Additions of boron were most profitable with spinach and sugar beets, less so on potatoes and least on oats. Mn supplements

acted the most favorably on oats with less effect on spinach, whereas potatoes scarcely seemed to require supplemental Mn fertilization. Chandler (10) found that stem-end browning of potato tubers was produced in the greenhouse on low boron solutions and a more severe symptom of boron deficiency in the tubers is described. Wallace (50) described K, Mg, Mn and B deficiency symptoms in fruit and vegetables and the use of "indicator" plants for diagnostic purposes is suggested, *e. g.*, globe beet, sugar beet or mangels for B or Mn; cauliflower, broccoli, Brussels sprouts or marrow-stem kale for Ca, Mg, B and N; swedes for Mg, B and P; and potatoes for K, Mg and Mn deficiencies are recommended.

Time and Method of Application of Fertilizers

Gray (20) presents evidence from results of experiments conducted in Pennsylvania indicating that applying a portion of the fertilizer in the plow furrow and the remainder in bands results in higher yields than where all is applied in bands. Fertilizers of 1-3-3 ratio were largely used. Iversen (24) indicated that his results are in good agreement with earlier investigations, in that a spring application of superphosphate and potash is considered best for corn, oats, cabbage and beets. A fall application of potash is best for potatoes, particularly if greater quantities of chloride-containing potash fertilizer should come into use. Michael (32) states that yields were lower when N fertilizer was added at 2 stages of growth than when all was added at the start. Starch and dry matter had a slight but uniform tendency to be higher in the 2-stage treatment. Total, protein and amide N were higher in the 2-stage treatment. Selke (38) found that supplemental late N fertilization caused increases in crude protein content of the dry material of potatoes up to 1 per cent; the pure protein of the tubers increased only 0.3 per cent.

Smith, Hommel and Kelly (39) have reported the results of a study in which consideration was given to the amounts of fertilizer applied, methods of fertilizer placement, sizes of seed pieces planted, distance of spacing seed pieces in the row and the responses of two varieties to these treatments. The factorial experiment consisted of 48 treatments. With the equal-depth band application of 1600 pounds 5-10-10 fertilizer at time of planting, the yields are no higher than with the 800-pound application; in fact, with the Sebago, it was some what lower. This indicates possible injury to the plants with the high rate of application under the conditions of this experiment. This is further indicated by the much larger yields obtained at the 1600-

pound application from the high-low band method and the one-half broadcast, one-half band application than from the equal-depth band placement.

At the 800-pound per acre rate of application, highest yields of Sebagoes were obtained from equal-depth band application and lowest from the broadcast-band method; whereas, with the Rural, highest yields were obtained from the high-low band, and lowest from the broadcast-band method. The Sebago outyielded the Rural at both rates of application and with every method of fertilizer placement except the high-low band at 800 pounds to the acre where yields were practically the same.

Yields from various distances of spacing seed-pieces in the row are influenced by method of placement of fertilizer. With the Sebago and at 11-inch spacing, highest yields are obtained from equal-depth band and high-low band methods of placement. At the 14-inch spacing, yields are highest with the high-low band placement and lowest at the equal-depth band placement. With close-spacing and at the rate of 800 pounds 5-10-10 to the acre, equal-depth band placement resulted in higher yields than from the two other methods of fertilizer application. At the 1600-pound per acre rate of application and the same spacing, however, equal-depth band placement of fertilizer resulted in lowest yields and high-low band placement resulted in highest yields. With the 14-inch spacing, the high-low band method of placement resulted in largest yields at both rates of fertilizer application. No increases in yields with equal-depth placement resulted from the 1600-pound application of fertilizer over the 800-pound rate; whereas, large increases resulted when applied in either of the other two methods.

Increases in yield from fertilizer application of 1600 pounds to the acre compared with those of 800 pounds varied from three to 43 bushels, depending upon the other factors involved. With both varieties, lowest yields were obtained from the combination of lower rate fertilizer application, the smaller size seed-piece, and the greater distance of spacing seed-pieces. Largest yields of Sebago resulted from the combination of closer spacing, the larger size seed-piece, and the larger application of fertilizer.

With the Sebago there is indication of some possible injurious action of the 1600-pound per acre application when all was applied in equal-depth bands. At the four combinations of size of seed-piece and distance of spacing and with equal-depth band placement of fertilizer, there was an average decrease in yield of 16 bushels to the

acre by the use of 1600 pounds compared with 800 pounds 5-10-10 to the acre. However, with high-low band placement, there was an increase of 50 bushels to the acre; and with the one-half broadcast one-half band placement, there was an increase of 64.5 bushels. Results from this preliminary study would indicate that there is some merit in the deeper application of commercial fertilizers for potatoes at least on certain soil types and under certain environmental conditions; also that heavier applications of fertilizer may be applied profitably when the fertilizer is placed deeper in the soil or farther from the seed-piece as compared with equal-depth band placement.

Absorption of Nutrients and Chemical Composition

Lorenz (32) found that N was the predominating fertilizer element affecting yield of potatoes on sandy loam soils in Kern County, California. Phosphorus gave slight response but K had no effect. Analyses of soluble nutrients in the petiole tissues indicated that if the plant contained less than 800 p. p. m. of nitrate approximately 1 month after emergence the yield would be decreased. Nitrate decreased rapidly as the plants matured. During the period of most rapid growth in the plants on plots without added P, soluble P was less than 70 p. p. m. Soluble K was never less than 10,000 p. p. m. The starch content decreased from 17 per cent in tubers produced without N to less than 13 per cent in tubers grown on plots receiving 210 pounds N per acre. Throughout the season, N was lower in all parts of the plants grown on the plots lacking N than in plants on plots receiving N. Phosphorus was low both in plants grown without N fertilizer and in those without P. Omission of N from the fertilizer greatly reduced the absorption of P by all parts of the plant analyzed. Potassium was high in all samples and was unaffected by any of the fertilizer treatments. Calcium was highest in plants grown without N and lowest in plants grown without P. Total ash accumulated in the top portions of the plants grown without N. Mature tubers harvested from plots liberally fertilized contained dry matter 21.0; N 0.037; P, 0.067; K, 0.489; Ca, O.008; Mg, 0.029; and ash 0.939 per cent of the fresh weight. Gusev (22) found that N, P_2O_5 and K_2O were absorbed by the potato plant during the whole period of vegetation. A maximum absorption of the nutrient substances by the green part of the plant was observed during the first period of growth (before blossoming). Jones and Plant (26) stated that deficiency symptoms of K and Mg agreed with the chemical analysis of the leaves. Certain

treatments were associated significantly with the ash, Ca, Mg, K and P contents of the leaves.

Chaminade (9) showed that analyses of different sized tubers of the same variety grown in the same soil show good agreement. The composition of the different varieties varies somewhat with the conditions under which they are grown. The K and P contents are strongly influenced by the soil composition and the fertilizer used. Vegetative organs such as potatoes show much greater "chemical plasticity" than, *e. g.*, cereals. From chemical analyses of potatoes the deficiency of certain elements in the soil can be detected. Numerous analyses give as average values, on a dry-weight basis, CaO 0.050, MgO 0.169, P_2O_5 0.405 and K_2O 2.98 per cent.

Barham, Kramer and Reed (2) found in preliminary experiments that at regular harvest and with potatoes as the previous crop Irish Cobblers contained 15.19 per cent starch when grown on upland soil, 15.41 per cent on fine sandy loam and 13.28 per cent on loamy sand. When grown on fine sandy loam Irish Cobbler tubers contained 14.31 per cent starch when the previous crop was oats, 14.64 per cent when the previous crop was alfalfa and 15.41 per cent when the previous crop was potatoes. Riethus (36) found that irrigation increases the total yield of starch. Large amounts of sewage are disadvantageous. Supplementary N, P and K fertilization were brought into action by irrigation. Amylase activity was highest with stall manuring plus N, P and K fertilization, but with storage a high starch destruction occurred. The least loss on storage occurred with manure-fertilized potatoes. Kosmat (30) reported that foliage leaves of early and medium-early potato varieties had smaller stomata than medium-late varieties and late varieties. The higher osmotic pressure (higher sugar content) of the cell sap of the earlier varieties (17.8 to 19.6 atms. compared with 12.7 to 17.8 in the later varieties) reduces the relative flexibility of the stomata. Plants with higher osmotic pressures *e. g.* early maturing, low-starch potatoes) draw water, with its dissolved nutrients from the soil more easily. Transpiration is reduced and the narrowed stomata, owing to increased osmotic pressure of the tissues, hinders the assimilation of CO_2. Plants with low osmotic pressures (late-maturing high-starch varieties) have easily and widely opening stomata that do not hinder assimilation and transpiration, but such plants are at a disadvantage in the assimilation of water and nutrients from the soil. In green, sound plants an antagonism exists between the osmotic pressure of the roots or of the entire plant and the mobility of the stomata. With advancing age the leaf tissue relaxes ow-

ing to syneresis and the stomata acquire a large flexibility so that CO_2 assimilation rises to a maximum. Potato plants with leaf roll disease, because of large increases in carbohydrates (due to phloem necrosis) that affect osmotic pressure have only small stomata openings, lowered transpiration and reduced assimilation owing to increased swelling pressure.

Vitamin Content of Potatoes

Varietal differences were observed in the ascorbic acid content of potatoes grown in different localities in New York State in three seasons by Karikka, Dudgeon and Hauck (28). High values were obtained for the varieties Katahdin, and Houma throughout the 3 years; the values for Chippewa tended to be low; whereas those for Irish Cobbler, Warba and Sebago were intermediate. Less consistent results were obtained for Earlaine annd Green Mountain. The ascorbic acid content of potatoes grown in different localities showed marked variation. Under the conditions of these experiments, neither soil reaction, the amount of N, P and K in the fertilizer, nor the addition of minor elements to soil to which a complete fertilizer had been added had a consistent influence on the ascorbic acid content of potatoes. Losses of ascorbic acid tended to occur more slowly in potatoes which were stored at 50° F. than in those stored at 40° F. About 2/3 of the ascorbic acid content of the raw tuber remained in the boiled potato.

Effect of Fertilizers on Cooking Quality

Tottingham *et al* (48) conducted greenhouse studies over a period of years to determine the cause of darkening in potatoes after boiling. The blackening of the potatoes depends most directly upon the record of the tubers planted. Discoloration was common in the varieties Rural New Yorker and Irish Cobbler but rare in Chippewa and Triumph. Differences in the rates of supply of the major nutrient elements and of iron (Fe) and boron (B) did not affect darkening. Neither did the omission of Mn, Cu and Zn. Deficiencies of B which brought about growth disturbances varying from leaf roll to breakdown of stem tips did not induce discoloration of boiled tubers. Subjecting the developing tubers to heat, drought or a combination of these factors did not cause a consistent discoloration of the cooked tuber. Internal brown spotting occurred in tubers subjected to less than 3.0 per cent moisture in the sand culture but this abnormality was not universally associated with blackening after boiling. Potatoes

were grown by Wallace and Wain (53) in the field and in sand cultures with various combinations of fertilizers and nutrient elements added. Approximately 2 months after harvest, stored samples were boiled for 25 minutes and the color was observed. Blackening occurred when the potatoes had been grown under a K-deficient condition (accentuated by high N) and under a deficiency of phosphates. Potatoes grown in Ca-deficient sand cultures showed purplish brown discolorations. The possible rôle of iron in the blackening phenomena is discussed.

Toxicity and Diseases

Exhaustive experiments by Uverud (49) indicated that the toxic action of sodium chlorate on cereals, potatoes and root plants had practically disappeared after two years. Starr, Cykler and Dunnewald (43) report that there was no significant relation between the prevalence of scab on potatoes grown under irrigation in Wyoming and either soluble salts, pH value, lime content, available P or available K in the soil. The incidence of scab was greatest in the plots that received the most irrigation water.

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